F460

Four-channel Fast Low-Current Measurement Device

User Manual

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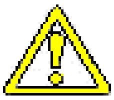
1 Safety Information

This unit is designed for compliance with harmonized electrical safety standard EN61010-1:2000. It must be used in accordance with its specifications and operating instructions. Operators of the unit are expected to be qualified personnel who are aware of electrical safety issues. The customer's Responsible Body, as defined in the standard, must ensure that operators are provided with the appropriate equipment and training.

The unit is designed to make measurements in **Measurement Category I** as defined in the standard.



CAUTION

According to installed options the F460 can generate high voltages as follows, present on the central conductor of the SHV (Safe High Voltage) output connector:

+ or – 3000 V DC at 0.33mA maximum

or

+ or – 2000 V DC at 0.5mA maximum

or

+ or – 1000 V DC at 1.0mA maximum

or

+ or – 500 V DC at 2.0mA maximum.

The hazardous live voltages on the SHV conductor are not accessible under the definitions of EN61010 but may nevertheless give a noticeable shock if misuse were to lead the user to come into contact with them. The user must therefore exercise appropriate caution when using the device and when connecting cables. Power should be turned off before making any connections.

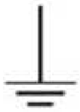
The unit must not be operated unless correctly assembled in its case. Protection from high voltages generated by the device will be impaired if the unit is operated without its case. Only Service Personnel, as defined in EN61010-1, should attempt to work on the disassembled unit, and then only under specific instruction from FMB Oxford Ltd.

The unit is designed to operate from +24VDC power, with a typical maximum current requirement of 300mA. A suitably rated power supply module is available as an option. Users who make their own power provision should ensure that the supply cannot source more than 3000mA.

A safety ground must be securely connected to the ground lug on the case.

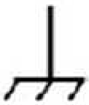
Some of the following symbols may be displayed on the unit, and have the indicated meanings.

Direct current



Earth (ground) terminal

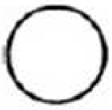
Protective conductor terminal



Frame or chassis terminal

Equipotentiality

Supply ON



Supply OFF

CAUTION – RISK OF ELECTRIC SHOCK

CAUTION – RISK OF DANGER – REFER TO MANUAL

2 Models

F460	F460 four channel electrometer with 4 independent channels
-XP30/20/10/05	Add positive auxiliary HV bias supply 3000V / 2000V / 1000V / 500V output, 1 watt
(-XN)	Add negative auxiliary HV bias supply
-S1	Add servo controller option
-IM10	Highest current range 10mA (1 mA is standard)

Example:

F460-XN10-S1	F460 with 1000V negative auxiliary HV bias output and servo control option

3 Scope of Supply

F460 model as specified in your order

MPSU0953: 24V DC power supply with 2.1mm threaded jack connector and C14 line input

USB memory stick containing:

User manual
PTC DiagnosticG2 software installation files

Terminal emulation program for testing ASCII communication

Test data

Optional items as specified in your order

4 Optional Items

All cable lengths can be customized upon request.

4.1 POWER SUPPLIES

PSU24-40-1: +24 VDC 40W PSU (universal voltage input, plug receptacle for standard IEC C14 three-pin socket) with output lead terminated in 2.1mm threaded jack.

PD-8: Eight output +24 VDC PSU, 19” rack mounting.

4.2 SIGNAL AND HIGH VOLTAGE CABLES AND CABLE ACCESSORIES

CAB-BNC-COLN-xx-BNC: Cable, coaxial low-noise, BNC jack to BNC jack, xx feet long.

ADAP-LEMO-BNC: Adaptor, coaxial, Lemo 00 male to BNC jack (fig 1 left).

ADAP-BNC-LEMO: Adaptor, coaxial, BNC jack to Lemo 00 female (fig 1 right)

Figure 1. Coaxial adaptors, Lemo-BNC

Note: only one adaptor ADAP-LEMO-BNC can be connected to the F460 at one time due to mechanical space constraints. If you intend to use all of the TTL monitor outputs, we recommend using Lemo to Lemo miniature coax (RG-178 or similar), and adapting to BNC if necessary at the receiving end using ADAP-BNC-LEMO.

CAB-L00-xx-L00: Cable, coaxial, Lemo 00 to Lemo 00, xx feet long.

CAB-SHV-xx-SHV Cable, coaxial HV, SHV to SHV, xx feet long.

4.3 DATA CABLES

ADAP-D9F-MINIDIN: AB450K-R RS-232 6 pin DIN male to 9 pin D sub female adaptor.

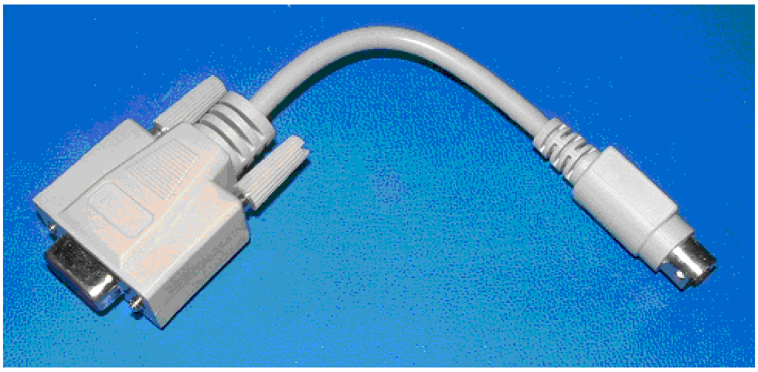


Figure 2. Serial adaptor cable

CAB-ST-xxP-ST Fibre-optic cable 1 mm plastic fibre ST terminated with color-coded sleeves, xx feet long.

CAB-ST-xxHCS-ST Fibre-optic cable pair 200 µm silica fibre ST terminated with color-coded sleeves, xx feet long.

5 Intended Use and Key Features

5.1 INTENDED USE

The F460 is intended to read out up to four input currents in the typical range +/- 1 nA to +/- 1 mA. Higher maximum currents can be specified. The currents may be signals from photodiode beam position monitors, Faraday cups, ionization chambers or other similar sensors. The 250 kHz maximum conversion rate permits good time resolution of fast-changing signals differing by many orders of magnitude to be measured simultaneously. The F460 can of course be used in any application where several small currents must be simultaneously measured.

The F460 includes a powerful real-time processor and memory which allows it to filter, analyze and buffer incoming data as fast as it is gathered.

Many sensors require a high voltage bias voltage. The F460 can be configured to include a suitable supply. However the incoming signals must be ground-referenced.

The F460 can be specified with a PID servo controller. A process variable is formed by arithmetic combination of the incoming signals, and the value of an analogue output is adjusted to keep it constant. A typical application is stabilization of the flux from a double-crystal X-ray monochromator, but it may be used for any application with similar requirements.

The primary means of communication with a host computer system is Ethernet. A serial interface is also available with ASCII communications protocol to allow simple connection to legacy systems. The F460 also provides a fibre-optic communication channel which allows it to control slave devices. A complete system can be built up around a single F460 in many cases.

The F460 has design features which make it tolerant of electrically noisy environments, but the place of use is otherwise assumed to be clean and sheltered, for example a laboratory or light industrial environment. The unit may be used stand-alone, or networked with other devices and integrated into a larger system. Users are assumed to be experienced in the general use of precision electronic circuits for sensitive measurements, and to be aware of the dangers that can arise in high-voltage circuits.

5.2 KEY FEATURES

Highly-integrated and compact device with on board signal conditioning, analogue to digital conversion, calibration, data buffering and host communications.

Four fully-parallel current measurement channels.

Independent range control on each channel.

Optional high voltage output for detector biasing with remote loopback for verification.

General purpose parallel input/output port with analogue outputs and inputs for monitoring and optional servo control.

Digital outputs (TTL) for monitoring (VFC emulation)

Gate input and output for triggering on external events, and trigger distribution.

On-board precision calibration source.

On-board position function calculation.

Servo controller option.

Ethernet interface with TCP/IP and UDP messaging.

Alternative RS-232, RS-485 and fast fibre-optic serial interfaces built-in. Selectable baud rates.

Slave devices can be connected to the F460 via the fibre optic interface.

6 Specification

6.1 CURRENT INPUTS

Number	Four, independent parallel
Operating principle	I-V convertor (transconductance amplifier) with four ranges
Dynamic current range	0.1 nA to 1 mA, bipolar
Individual current ranges	Four, independently selectable for each channel. Range 1: +/- 1 mA full scale Range 2: +/- 100 µA full scale Range 3: +/- 10 µA full scale Range 4: +/- 1 µA full scale
Input impedance	≤ 40 Ω
Input protection	Back to back diodes and spark gaps
Noise	< 0.01% of full scale rms, 1 ms averaging
Absolute accuracy	Readings within +/- 0.1% full scale relative to a traceable external standard current source
Stability	Output drift < 10 ppm hr^{-1} +5 ppm $C^{-1}hr^{-1}$ with recalibration Output drift < 20 ppm hr^{-1} +10 ppm $C^{-1}hr^{-1}$ without recalibration
Analogue bandwidth	DC to ≥ 40 kHz (- 3dB)
Gain uniformity	Better than 0.1% across all channels after calibration
Digitization	16 bit successive approximation bipolar, 250 kHz, fully parallel
Downsampling	Averaging adjustable from 1 (4µs period) to 250000 (1s period)
Simultaneity	All channels converted at once (within 200ns)
Accumulation	Charge accumulation provided via numeric integration
Triggering	External trigger line can start, pause and stop acquisition via TTL level signal to gate input Input impedance 2.5 kΩ
Digital filtering	Block averaging of successive conversions for each reading, 1 to 250000 samples
Data buffering	On-board buffering of up to 50000 contiguous samples at any data rate up to maximum

6.2 CALIBRATION

Method	Fully automatic calibration of current inputs using internal current sources
Calibration currents	Two internal precision calibration sources, 833 nA and 83.06 μA, used for automatic calibration
Calibration values	Gain and offset stored in NVR for each range of each channel
Sensor compensation	Independent calibration input available to compensate sensor variability
Other calibrations	Gain and offset parameters stored for general purpose analogue inputs and outputs, and for high voltage

6.3 TRIGGERING AND BUFFERING

Data buffering	On board buffering of up to 50000 contiguous readings at any data rate up to maximum
Gate input	TTL signal on gate input can start, pause and stop acquisition. Input impedance 2.5 kΩ
Trigger modes	internal (autorun) Custom control of start, pause and stop conditions using gate input and internal buffer counts

6.4 MONITOR OUTPUTS AND GENERAL PURPOSE INPUT/OUTPUT

Analogue inputs	Two, 16-bit +/- 10 V. Accuracy better than +/- 0.5% of full scale
Analogue outputs	Four, 16 bit +/- 10V (used for servo and monitor outputs). Accuracy better than +/- 0.1% of full scale
Digital outputs	Four, TTL levels into 50 Ω (used for monitor outputs)

6.5 HIGH VOLTAGE OUTPUTS

Number	One (optional)
Output power	1 watt
Voltage options	20 to 200 V. Line <0.01%. Load <0.05%. Ripple < 0.01% 50 to 500 V. Line <0.01%. Load <0.01%. Ripple < 0.01% 200 to 2000 V. Line <0.001%. Load <0.01%. Ripple < 0.01% 300 to 3000 V. Line <0.2%. Load <0.3%. Ripple < 0.075% All options available as positive or negative polarity (factory selection)
HV monitoring	Voltage divider on output (20 MΩ), 16 bit digitization with calibration

6.6 COMMUNICATION INTERFACES

Ethernet	Ethernet 10/100/1000 Base T, TCP/IP and UDP
RS-232	115.2 kbps/ serial
RS-485	115.2 kbps/ serial
Fibre optic	10 Mbps, binary serial protocol, for control of slave devices and integration into FMB Oxford system architectures

6.7 CONTROLS AND INDICATORS

Controls	Two rotary switches for communications mode and fibre optic loop address Push button processor reset
Indicators	Four green status LEDs “HV on” orange LED

6.8 POWER INPUT

Voltage	+24V DC (+/- 2V)
Current	300 mA typical, 500 mA maximum. 500 mA PTC fuse

6.9 CASE

Format and materials	Stainless steel sheet metal case with mounting flanges
Protection rating	The case is designed to rating IP43 (protected against solid objects greater than 1m in size, protected against spraying water)
Weight	1.28kg (2.82 lb)

6.10 ENVIRONMENT

Operating	10 to 35 °C (20 to 30 °C recommended) < 70% humidity, non-condensing Vibration < 0.1g all axes (1 to 100Hz)
Storage	-10 to 50 °C < 80% humidity, non-condensing Vibration < 2.0g all axes (1 to 100Hz)

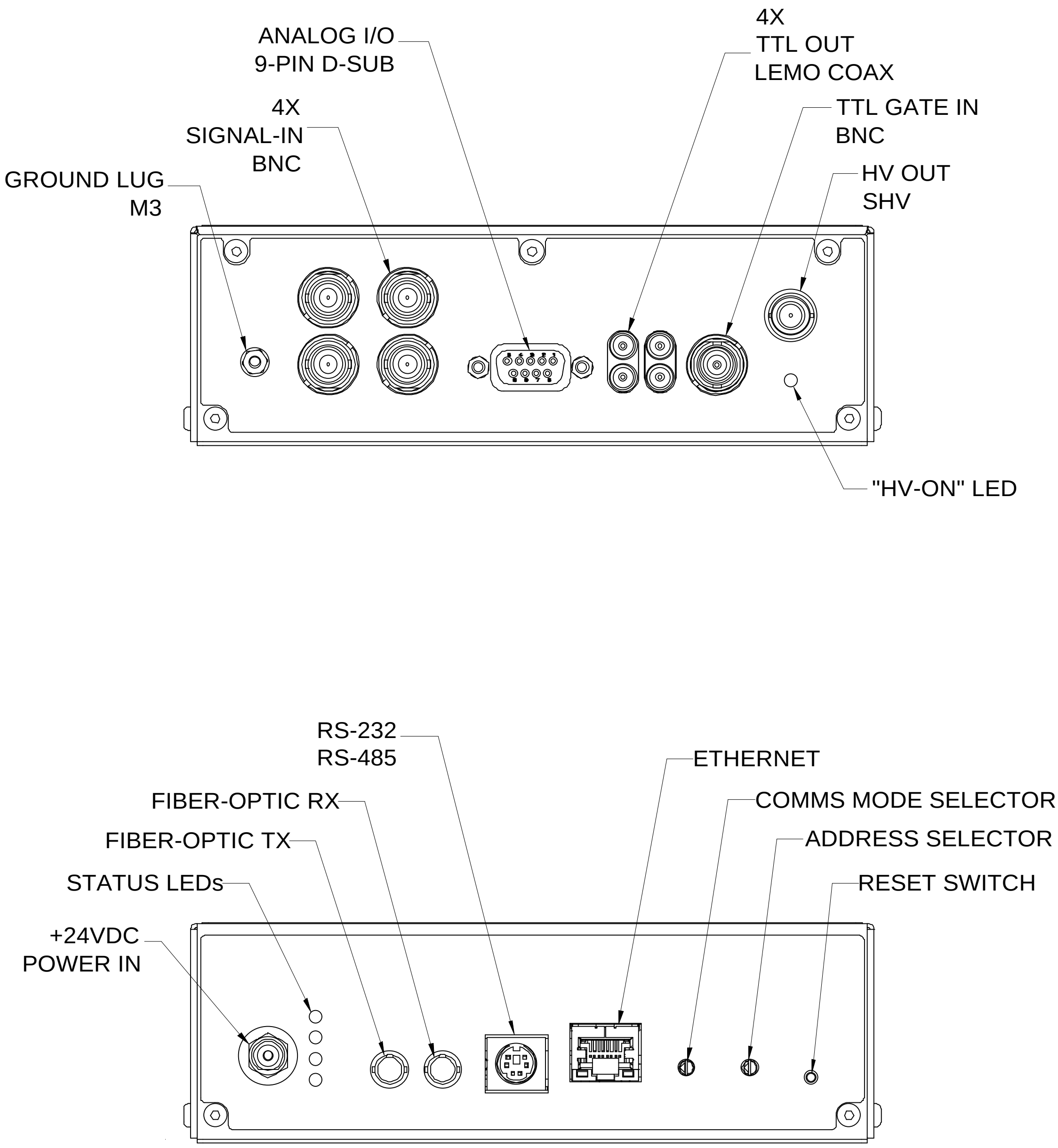


Figure 3. F460 front and rear panels

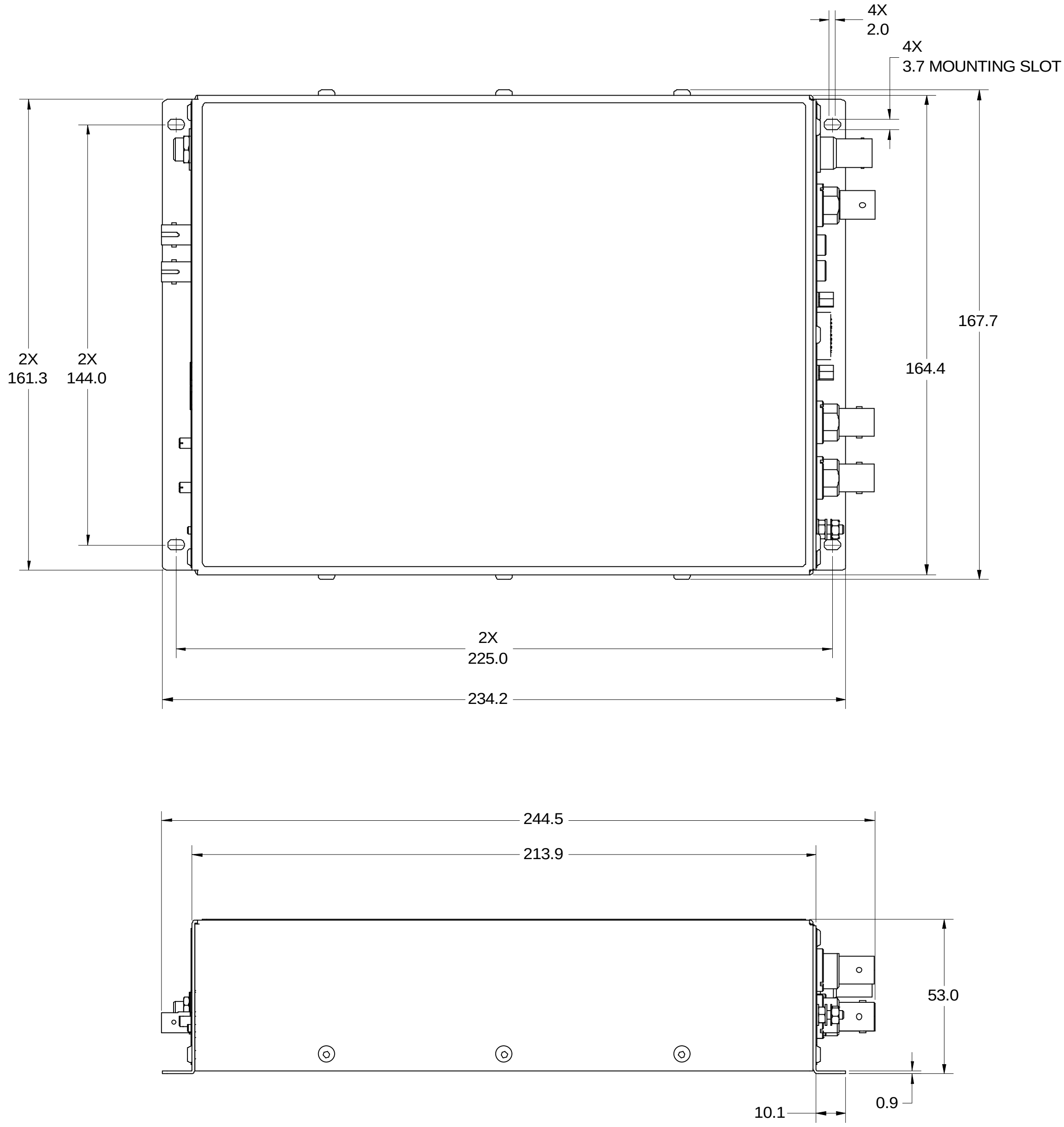


Figure 4. F460 case plan and side views. Dimensions in mm

7 How the F460 Works – An Overview

The F460 is a very flexible instrument which uses a high performance current to voltage conversion circuits, fast ADCs and powerful on-board processors. This section gives you an overview of how incoming signal current is turned into readings, and the main features of the device. Full details are in the later sections of this manual.

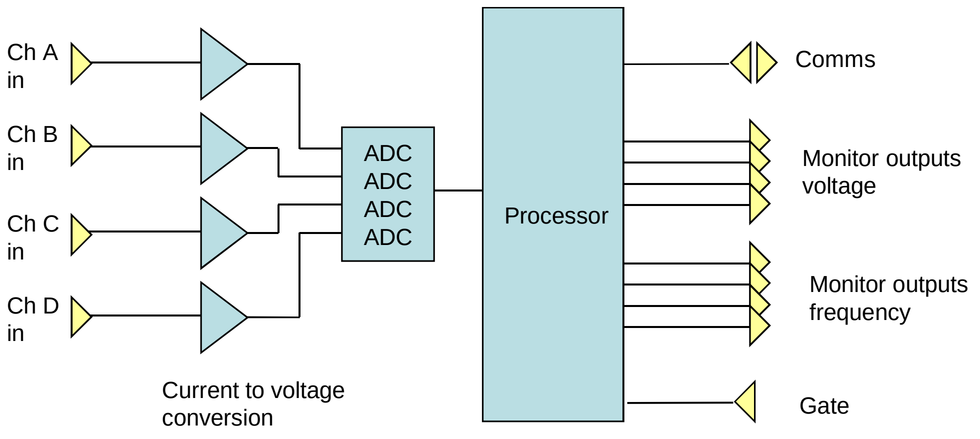


Figure 5. F460 block diagram

The F460 has four parallel input channels which convert small currents to measureable voltages. The full scale ranges for the conversions can be independently set for each channel. The voltages are measured simultaneously by ADCs (analogue to digital converters). The resulting binary values are converted to current readings in amps by applying calibration factors. These currents can be requested over the communication link, and are also used to drive the monitor outputs. Let's start by looking at the measurement process in a little more detail.

7.1 CURRENT MEASUREMENT PROCESS

The simplest current to voltage convertor is simply a resistor. The current flowing through the resistor produces a voltage according to Ohm's law. The performance is improved greatly if the resistor is placed into the feedback loop of an operational amplifier circuit, as shown below.

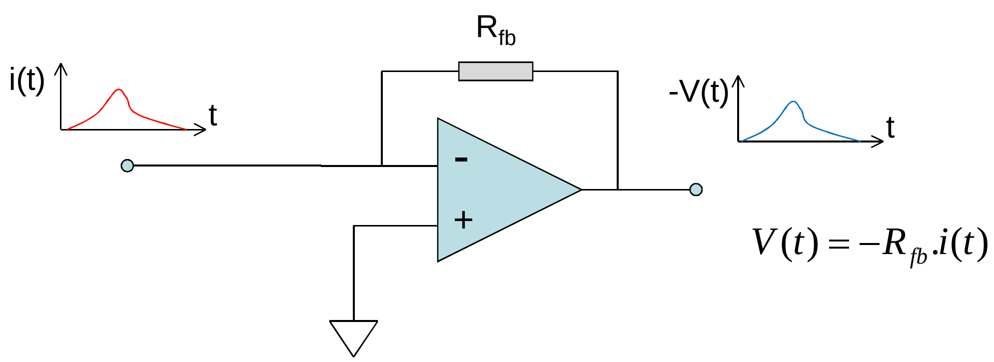


Figure 6. Current to voltage conversion

The highest current you can measure depends on the size of Rfb and the voltage range of the ADC that reads the output of the current to voltage conversion. The lowest current you can measure depends on the resolution of the ADC, and more often the noise in the system. The F460 allows you measure over a wide dynamic range by providing four amplifier circuits per channel, with feedback resistors that differ by a factor of 10 between the ranges. The amplifier to use is selected under software control.

7.2 FILTERING AND AVERAGING

Generally we don't wish to see very high frequencies in the signals being measured by the F460. They are most likely to be interfering noise. Also, an ADC should not be presented with signals with frequencies exceeding 50% of its sampling rate, or you will get confusing aliased results. The F460 therefore includes low-pass filters before the ADC inputs which roll off frequencies starting around 40 kHz.

Once the signal has been digitized by the ADC, we have the opportunity to further filter the signal in the digital domain. This is very helpful if you need to extract small signals from a noisy background. The F460 provides a block averaging facility that permits you to select between 1 and 250000 individual conversions per measurement, and thus change the effective integration time. This also allows you to control the data rate, and to filter out particular noise frequencies. For example, if you see interference at 60 Hz, then setting the integration time to 16668 μsec will eliminate it completely.

7.3 TRIGGERING AND BUFFERING

In many cases you will need to coordinate the F460 measurements with external events. You can preset the F460 with all the measurement parameters such as current range, averaging settings and so on, then initiate it ready to respond to a trigger signal. Measurements will start as soon as the trigger arrives. Advanced triggers allow you to pause the measurement when the trigger line changes again, or when a certain number of readings have been taken.

When data rates are high, they may exceed the capacity of the communications link and the host computer system. If you don't care about missing readings, then this is of no particular concern – you will just see the subset of the data that can be transmitted. However you may particularly want to see fast data that is contiguous in time. In the manner of a digital oscilloscope, the F460 allows this by streaming data into on-board buffer memory. The data can then be sent to the host computer without the limitations of communications rates. This facility is particularly useful when you have a short repeating pulsed signal with intervals between for the data to be recovered.

7.4 SELF TESTING AND CALIBRATION

The F460 can calibrate itself on all channels and all ranges fully automatically, and it stores the resulting factors so that it can provide results in physical units (amps or coulombs). You can also turn on the calibration currents at any time and send to any channel to check that the device is working correctly.

Although the F460 may be reading current very accurately, that does not mean that you get accurate readings from your sensor. The sensor will have its own gain and offset characteristic, and if you have a quad sensor, it is unlikely that the four parts have identical response. To handle this, the F460 includes a further set of calibration parameters that you can set to compensate the response of a sensor system. This allows you to “flat field” a detector, for example.

7.5 MONITOR OUTPUTS

The F460 has monitor outputs, both analogue voltage and frequency (TTL pulses). These correspond to the currents being measured on each channel, relative to the full scale in use. They respond to any sensor compensation you are using. You can also ask the F460 to put out computed X and Y position values on two of the monitor outputs instead.

8 Installation

8.1 MOUNTING

The F460 may be mounted in any orientation, or may be simply placed on a level surface. A fixed mounting to a secure frame is recommended in a permanent installation for best low current performance, as this can be degraded by movement and vibration. Four M3 through holes are provided in the base on a 225 mm by 144 mm rectangular pattern (see Figure 2).

The mounting position should allow sufficient access to connectors and cable bend radii. 100 mm minimum clearance is recommended at either end of the device.

Best performance will be achieved if the F460 is in a temperature-controlled environment. No forced-air cooling is required, but free convection should be allowed around the case.

8.2 GROUNDING AND POWER SUPPLY

A secure connection should be made using a ring lug, from the M3 ground lug to local chassis potential. This is the return path for any high voltage discharge passing via the F460.

+24 VDC power should be provided from a suitably-rated power supply with the following minimum performance:

Output voltage	+24 +/- 0.5 VDC
Output current	1000 mA minimum, 3000 mA maximum
Ripple and noise	< 100 mV pk-pk, 1 Hz to 1 MHz
Line regulation	< 240 mV

The F460 includes an internal automatically re-setting PTC fuse rated at 500 mA. However the external supply should in no circumstances be rated higher than the connector limit of 5 A.

8.3 CONNECTION TO SIGNAL SOURCE

8.3.1 Example set up

Figure 7 shows an example installation in schematic form. A diode array measures the position of a radiation beam. The F460 delivers data and receives commands from a host computer system over Ethernet. Serial RS-232 or RS-485 could also be used, but this will limit the data rate to the host. A trigger input to the gate connector allows measurements to be synchronized to an external event such as a “beam present” signal.

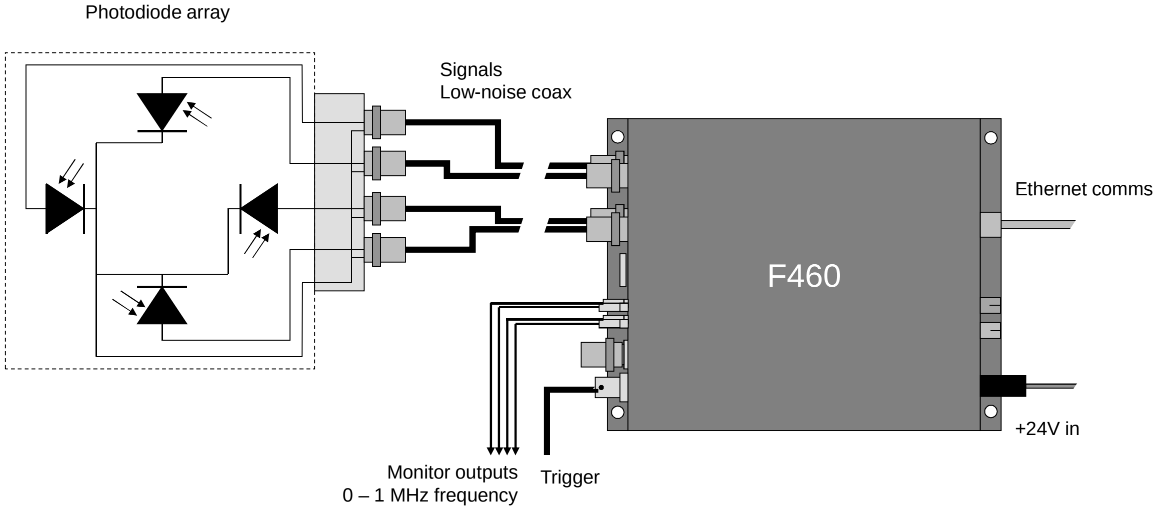


Figure 7. Schematic example: basic F460 installation for diode readout

Figure 8 shows another installation example to illustrate some other options. The F460 is in this case reading out quadrant ionization chamber electrodes, and it also provides the bias voltage for the chamber. The biased electrode is shown schematically behind the readout electrodes: it will be the anode or cathode of the chamber depending upon the bias polarity. In this case the loop for the measured current is completed through the bias voltage lead and the bias power supply module in the F460.

The analogue output connector is being used to connect a device such as a DC-controlled positioning motor that forms part of a servo stabilization loop (the –S1 option is required to use this feature).

The F460 is interfacing an M10 general purpose I/O unit as remote slave device via fibre optic. The M10 might be connected to a power supply or other device that is hundreds of metres away.

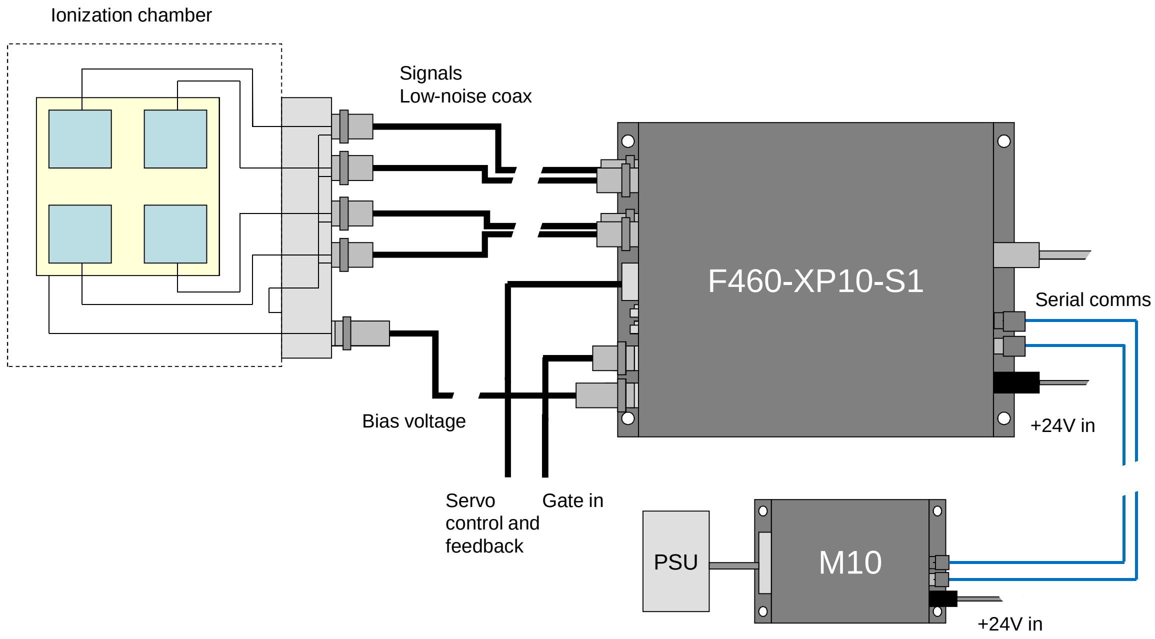


Figure 8. Schematic example: F460 installation for ion chamber readout

8.3.2 Cables

The F460 measures small signals, down to below 1 nA. Cable quality is vital to obtaining good noise performance. Well-made screened cables are essential for the current inputs, and you should try to minimize the length, while being mindful to remove the F460 from any areas with a high radiation background. If there is any risk of vibration or movement, then the use of low-noise anti-triboelectric coaxial cables is strongly recommended for the signal inputs. A suitable type is Belden low-noise RG-58 9223. Other types with equivalent specification can be used.

The high voltage cable should be coaxial with a DC rating sufficient for the maximum voltage you expect to use. RG-59 is a good choice for most uses, with a nominal DC rating of 2.1 kV. You can use the widely-available RG-58 coaxial cable with BNC connectors for the gate input.

8.3.3 Signal current path

The currents measured by the F460 must be allowed to return to their point of generation. Depending upon the application and the installed options, the return path may be via the high voltage supply, and/or via the facility ground and the F460 case. If there is no return path, then you will see no current, or erratic readings. You may see current initially if there is no return path, especially if the signal is small, as charge can be provided from various stray capacitances, but this may fall away or become unstable.

The currents you are measuring pass along the coaxial signal cable cores to the F460 inputs. The current for the operational amplifier action comes from the local circuit ground via the power supply providing the voltage rails for the amplifier devices in the F460.

In the case of an ionization chamber or similar device, where the F460 is providing the bias to an anode from the optional high voltage module, the subsequent return path for the current is through the HV module (Figure 10), to complete the circuit back to the anode.

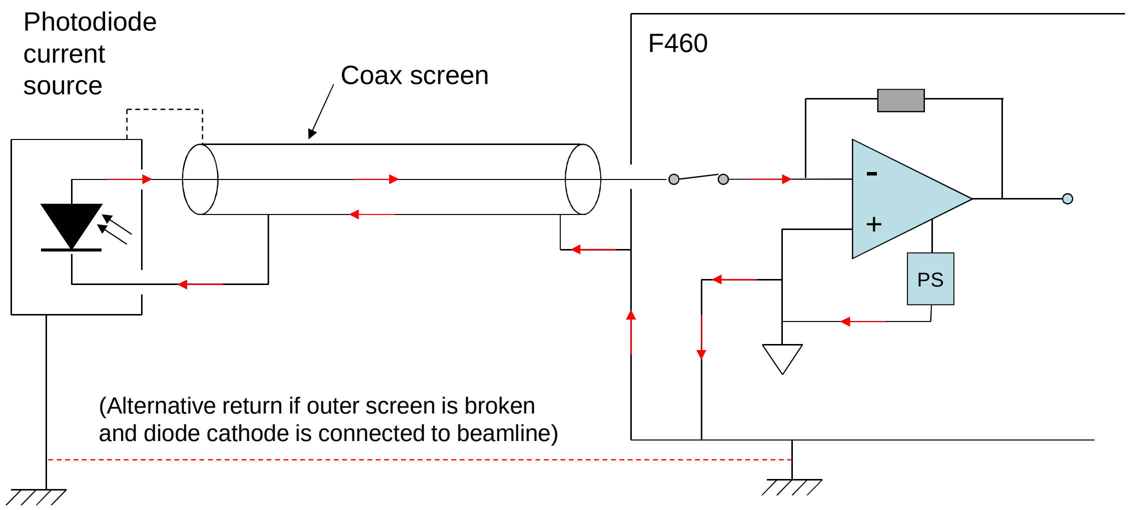


Figure 9. Current return path: photodiodes

Figure 10 shows current return paths for an ionization chamber where a high voltage module in the F460 is biasing the chamber. If you are using an external high voltage supply, then you must ensure that it shares a common ground with the F460 to complete the current path.

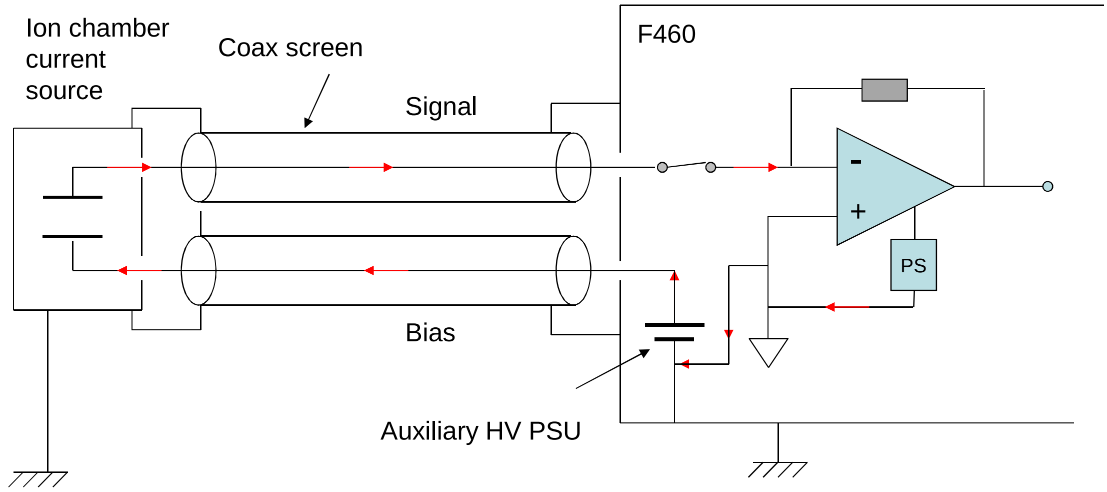


Figure 10. Current return path: ionization chamber bias provided by F460 HV module

9 Getting Started Using the PTC DiagnosticG2 Host Software

The PTC DiagnosticG2 was supplied with your F460, and the latest versions are available for download at www.ptcusa.com. Even if you intend to use your own host software, it can be very helpful to use the Diagnostic to check out the device and to become familiar with its features.

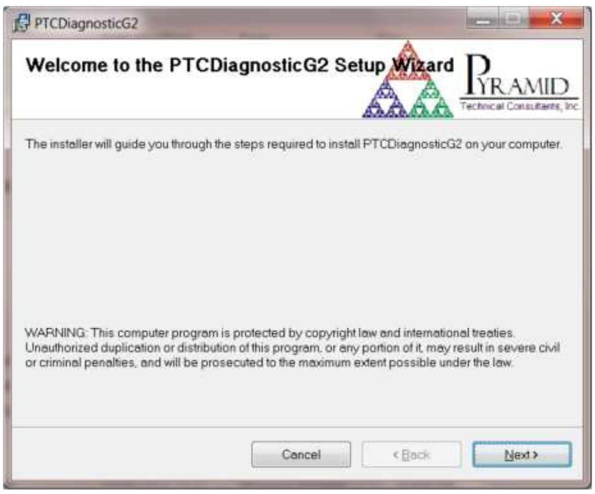
The PTC DiagnosticG2 is a stand-alone program which allows you to read, graph and log data from the F460, and set all the important acquisition control parameters. For some applications, or for initial work, it may be adequate for all of your data acquisition needs. The Diagnostic uses the same function library that is exposed for users who develop their own host applications, and therefore also serves as a software debugging aid.

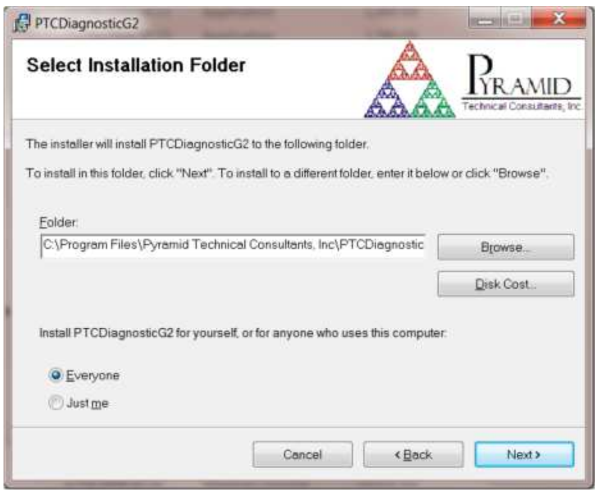
9.1 INSTALLATION

PTCDiagnosticG2 is a Windows program which has been tested on Windows XP, Windows 7 and Windows 8. It is installed from an msi file using the standard Windows installer utility. It also runs under Linux and has been tested with the Ubuntu distribution. There is no installer for Linux; contact Pyramid Technical Consultants, Inc. to get the latest suite of installation files and detailed instructions if you wish to run under Linux. The remainder of this section assumes a Windows 7 installation.

Copy the installer file PTCDiagnosticSetup-Vx_xx.msi to the hard drive of the host computer, where x_xx is the version of the Diagnostic program. The host PC must have a standard Ethernet port.

Install the PSI Diagnostic by running the installer, and following the screen prompts. During the process, depending on your account settings, Windows User Account Control may prompt you to allow the necessary changes. The installer will create a subdirectory on the Program Files directory, place a shortcut on your desktop and an entry in your start list.





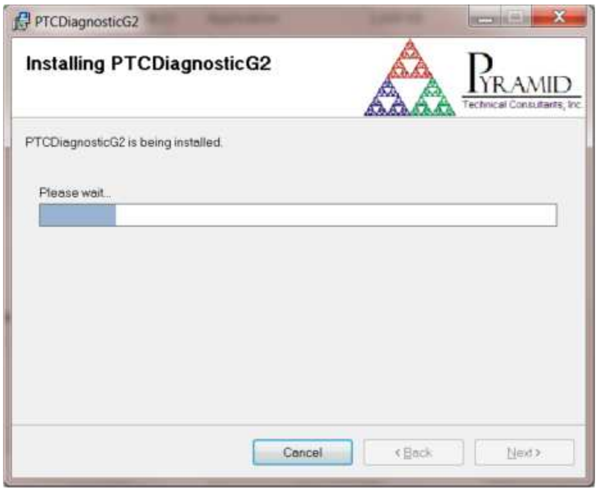


Figure 11. PTC DiagnosticG2 installation

Once the program has installed, you can run it at once. If you wish to view the files that have been installed, navigate to Program Files\Pyramid Technical Consultants, Inc.\PTCDiagnosticG2.

If you are updating your version of the Diagnostic, you may simply run the new installer and the relevant items will be updated. If you wish to regress your version, you should first uninstall the program using the Windows “Remove Programs” utility, then run the installer for the earlier version in the usual way.

You can have both the earlier PSI Diagnostic program and the PTC DiagnosticG2 installed on the same computer. If you wish to run them both simultaneously, you must run PTC DiagnosticG2 first.

9.2 CONNECTING TO THE F460

The following steps take you through the process of connecting to the device.

1) It is simplest to start with a direct connection from your host computer to the F460 using a CAT5 or CAT6 Ethernet cable as shown below. The network cable can be a patch or a crossover type – the F460 automatically adjusts itself to suit.

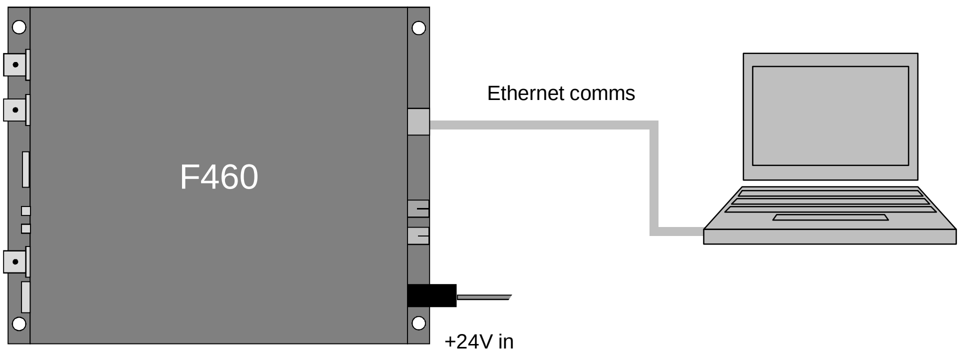


Figure 12. Direct Ethernet connection

Once you have established reliable communication, and set a suitable unique IP address, then you can move the F460 onto a general local area network and work under DHCP address assignment if required.

2) The device is set with IP address 192.168.100.20 at shipment. Once you have a connection you can change this setting as required. Set up your host PC Ethernet port with a fixed, non-conflicting valid IP address in the same subnet range. For this example, we've used 192.168.100.177.

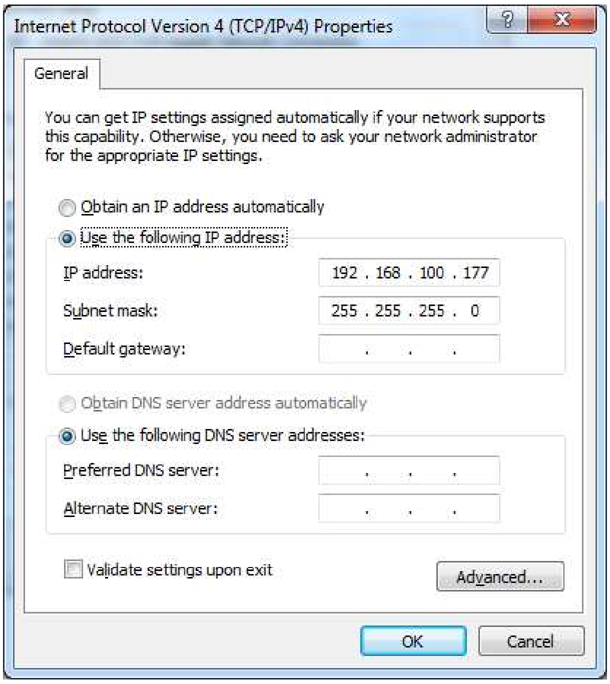


Figure 13. Configuring the IP address on the host computer

3) Turn on 24 V DC power to the F460, but make no other connections. While the device is booting, three lower LEDs on the rear panel cycle. When the device is ready, the “Active” and “Power” LEDs only should be illuminated.

4) Make the Ethernet connection from the host PC to the F460. You should see activity on the LEDs that are mounted in the F460 RJ-45 connector as the port negotiates with the computer. Check that you can ping the device from a command window prompt.

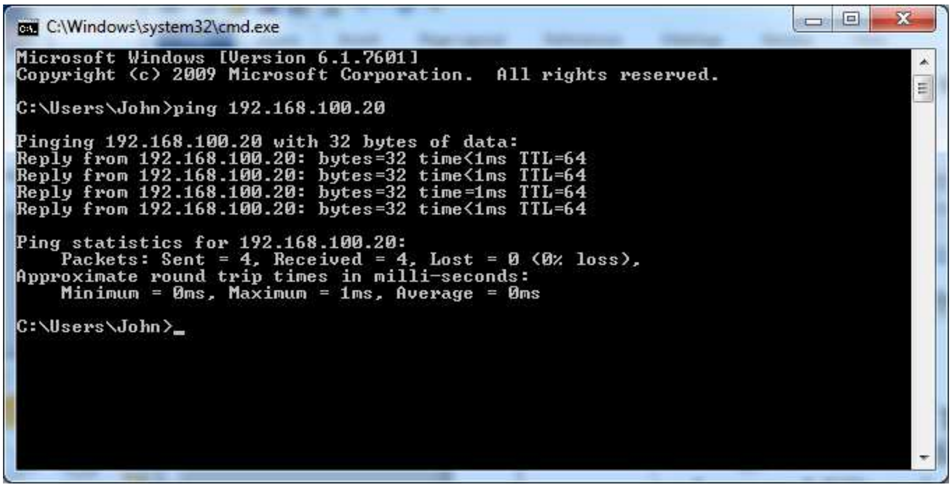


Figure 14. Ping test of the Ethernet connection

The Windows firewall may block communication with the F460. It is simplest to start by turning off the firewall while you are testing. To maintain security, you can disable any wireless adaptor on the computer while you are doing this. Once you have established communication, then you can try restoring the firewall if needed, and set up permissions for the PTC Diagnostic and the F460 RPC (port 111) to communicate through the firewall. Most users prefer to keep instrumentation, and the computers controlling it, isolated from the internet, and the firewall can then be disabled without concern.

6) Start the PTCDiagnosticG2 software. It will start with the Discover Devices dialog open. Click on Discover Controllers (

) and the software will search all IP addresses within its available network looking for compatible Pyramid devices

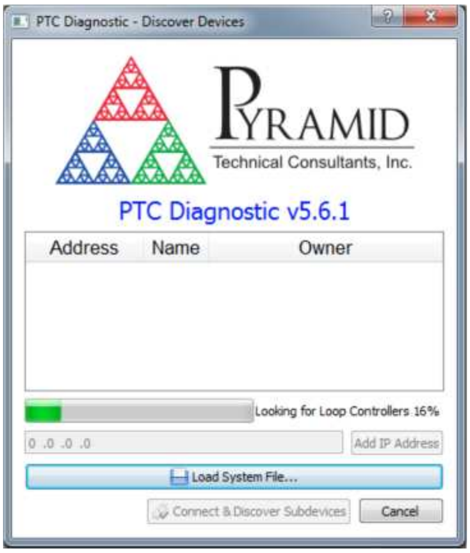


Figure 15. Discover devices in progress

Since you have the simplest possible network, it should find only the F460 you are working with. The discovered devices may include Pyramid tools such as the A60 recovery utility. You can ignore these.

When you click on the discovered F460 entry in the list to highlight it, the Connect and Discover Subdevices button () is enabled. Click on this to establish the connection to the F460.

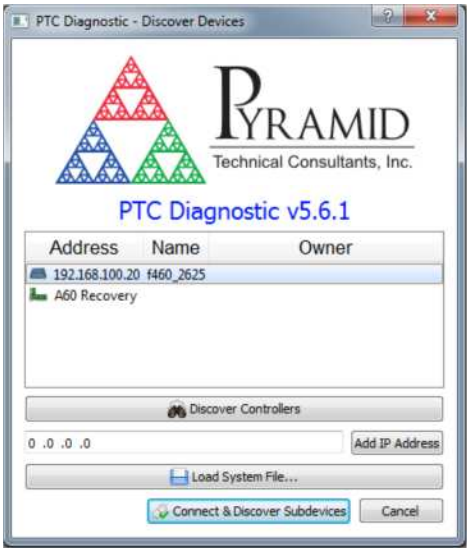


Figure 16. Ready to connect to the F460

A window for the F460 will open, and you will see messages in the message area as the F460 adds your PC as a host.

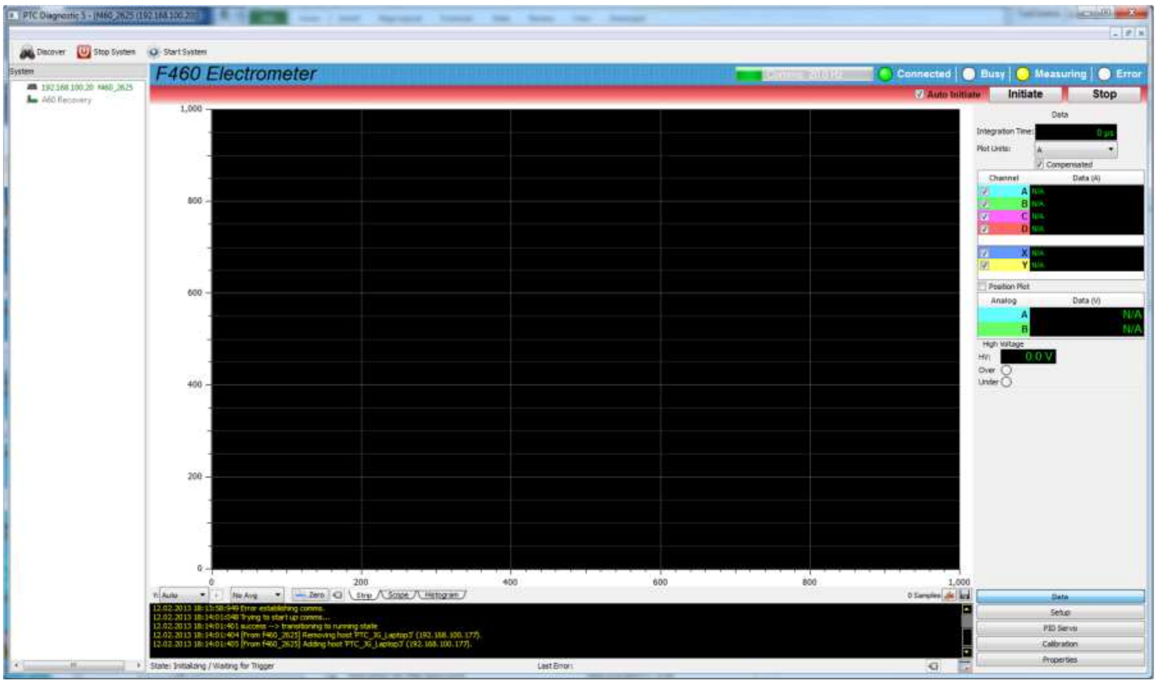


Figure 17. Opening the F460 window

The F460 user interface window is divided into two halves, graphics and data on left and right respectively, plus a top banner area. Below the graphic is a message window which reports all the commands issued to the F460 by the PTC Diagnostic program, and the corresponding acknowledgements. Generally you can ignore this display, but it will be valuable for diagnosis if you have any operating problems. The data area on the right changes according to which display option you select with the option buttons at the bottom.

We'll now describe the various controls and displays.

9.3 SCREEN LAYOUT – TOP BANNER

Figure 18. Top banner

The top banner contains the following indicators:

Comms bar	When moving, this indicates that messages from the F460 are being received by the PTCDiagnosticG2. The message frequency is displayed.
Connected LED	When lit, this indicates that communications are valid and the system is not in error.
Busy LED	When lit, this indicates the F460 is busy and cannot respond to inputs, for example while performing an automated calibration sequence.
Measuring LED	When lit green, this indicates that data acquisition is occurring. When lit yellow, this indicates that an acquisition is initiated but that the F460 is waiting for a trigger.
Error LED	When lit, the F460 has logged a communication error. The details are displayed in the message area.
Auto Initiate	Checking this box causes the software to automatically initiate a new acquisition whenever you change any acquisition parameter.
Initiate	This button starts data acquisition, if trigger conditions are satisfied.
Abort	This button terminates any acquisition in progress.

9.4 SCREEN LAYOUT – MESSAGE LOG AREA

Figure 19. Message area

This area shows all the commands and responses between the F460 and the host system, plus any F460 errors, which are shown in red. You can clear the messages with the Clear Log Display button () and you can clear latched errors with the Clear Last Error button ().

9.5 SCREEN LAYOUT – RIGHT HAND TABS

9.5.1 Data tab

The Data tab displays the instantaneous values of all analogue input values, including the four measured currents, plus the computed X and Y positions that the currents imply if they come from position sensors. If any current is overrange, it is highlighted in red. The values are refreshed whenever the F460 is acquiring data.

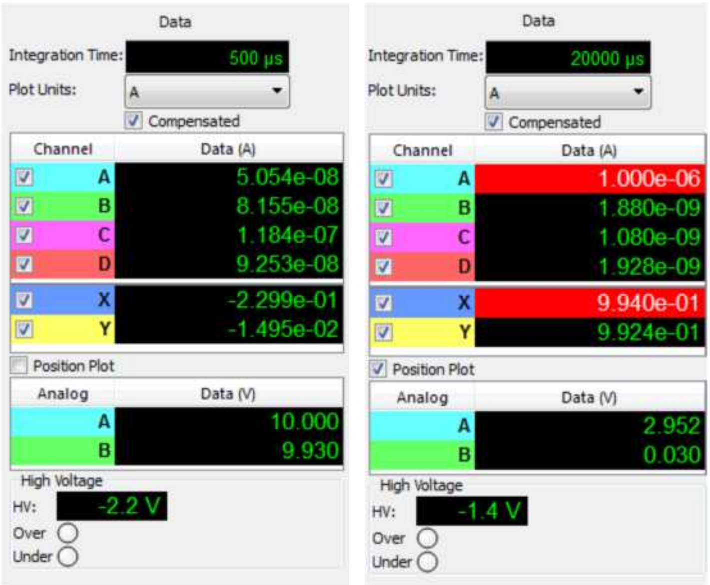


Figure 20. Data tab; current overrange indication

The Plot Units drop down allows you to display the readings in amps (exponential notation) or mA, µA, nA. The selection of display units has no effect on the way that data is acquired or logged.

If you have the Compensated box checked, then the values (and the plotted data) will have the sensor compensation gains and offsets applied. Uncheck this box if you want to be certain of an accurate absolute current measurement. Note that this control only affects the result shown on the PTC DiagnosticG2, and does not affect the values going to the F460 monitor outputs. If you have selected the monitor outputs to show sensor values, then the sensor gain and offset are always applied to them.

The Position Plot check box turns on graphing of the X and Y position values.

The Over and Under indicators are alarms that are set if the high voltage readback goes out of tolerance. This feature will be supported in a future firmware release.

9.5.2 Setup

The Setup tab is where you set up acquisition parameters, control high voltage supplies, and establish trigger settings. When you have found a useful set of parameters, you can save the configuration to on-board non-volatile memory using the

button. The values will be restored when the F460 next starts up, with the proviso that the HV will not be enabled.

There are two sub-tabs.

9.5.2.1 Measuring sub tab

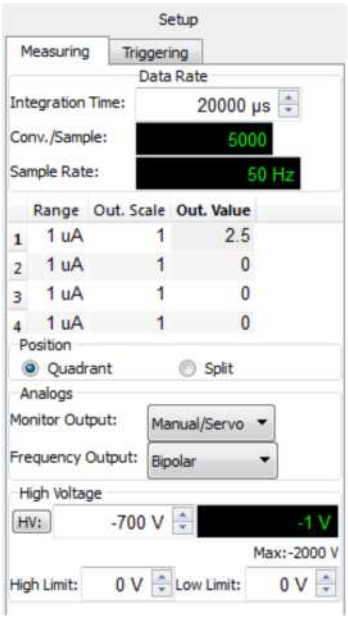


Figure 21. Setup tab: measuring sub-tab

The integration time parameter is where you control the amount of averaging the F460 processor will do to the incoming ADC values to generate a sample. As you alter these values, the read backs below show the resulting number of conversions per sample and sample rate. The minimum you can select is 4 µsec (one conversion per sample, sample rate 250 kHz) and the maximum is 1000000 µsec (250,000 conversions per sample, sample rate 1 Hz). This range gives you great flexibility in optimizing signal to noise ratio, time resolution, and data rate.

Each channel has an individual range drop down allowing you to select from the four available full scale ranges.

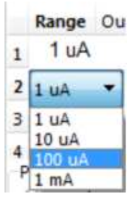


Figure 22. Range select control options

The Out.Scale parameter allows you to alter the gain of the mapping from measured value to monitor voltage and frequency. You can set the scale value between 0.02 and 2.0. A setting of 0.5 would map +/- 50% of the full scale current range onto the nominal monitor ranges (+/- 10V, 0 to 1 MHz), for example. See Section 15 for more information on the monitor outputs.

The Out.Value fields are enabled when you select Manual/Servo

(

) for the monitor output mode. They allow you to set the analogue output voltages directly. If you have the –S1 servo option and the servo is enabled, then the servo algorithm assumes control of the outputs.

The Position selection allows you to choose the position function that will be calculated in real time by the F460. Quadrant mode is applicable if you have a quadrant (2D-sensing) geometry sensor; split mode is applicable if you have one or two split electrode (1D sensing) sensors. See Section 14 for more information about position calculations.

The Monitor Output dropdown allows you to select the data that is sent to the analogue voltage and TTL frequency monitor outputs.

Figure 23. Monitor output choices

Current	Map the full scale currents onto the monitor ranges.
Sensor	Map the sensor compensated values onto the monitor ranges
Position	Map the position function results onto the first two monitor output ranges
Manual/Servo	Allow direct control of the analogue outputs. If PID enabled, use first one or two analogue outputs for servo process control.

The Frequency Output selection gives you control over how the selected monitor output value is mapped onto the monitor frequency output range. See Section 15 for more information on the monitor outputs.

The HV controls allow you to set the voltage, and enable or disable the supply. If you have a negative HV module installed, then you must enter negative numbers. The polarity and maximum voltage available from the installed HV module is displayed. The

Over and Under levels set tolerance for the high voltage readback. This feature will be supported in a future firmware release.

9.5.2.2 Trigger sub tab

The Trigger sub-tab is where you set up the trigger conditions. There are various trigger modes available. The basic Internal triggering without buffering will always show you a real time response on the PSI DiagnosticG2 display. For more complex triggering requirements and high time resolution, the Custom trigger controls allow you to define in detail the conditions for starting, stopping and pausing acquisitions.

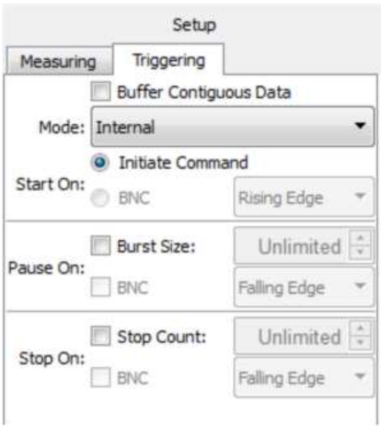


Figure 24. Setup - Trigger sub-tab

The simplest trigger mode is Internal with no buffering. Once you click Initiate, the F460 acquires data at the rate determined on the Measuring sub-tab, and streams it to the host computer in real time. The fraction of points you will capture is given by the communication rate as displayed in the top banner divided by the sample rate.

Using the F460 on-board data buffer by checking Buffer Contiguous Data allows this rate limitation to be removed, up to file size limits that are imposed by available memory. Checking the Buffer Contiguous Data box (Buffer Contiguous Data) and selecting a finite stop count up to the maximum of 65535 samples allows time-resolved acquisitions at high instantaneous rate. See Section 13 for further details of triggering and buffering.

You can choose to start, stop and pause acquisitions on edges detected by the F460 on the gate input. You can choose to stop or pause acquisitions when certain numbers of samples have been acquired.

Full access to the buffered and gated acquisitions is available using the Custom triggering mode. There are also a number of pre-defined triggering modes, mainly for backwards compatibility with other Pyramid products.

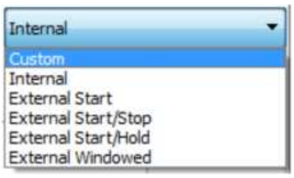


Figure 25. Triggering modes

9.5.3   PID servo tab

The servo tab is enabled if you have the –S1 option on your F460, otherwise it is grayed out. See Section 24 for information on using the servo feature.

9.5.4   Calibration tab

The F460 stores four types of internal calibration, which are shown in sub-tabs. The calibration current sources are used for the automatic current calibration process, but they can also be enabled directly for fault-finding. When the drop down control is set to None, the calibration sources are connected to ground. The Internal Low setting enables the 833 nA source and directs it to the selected channel. The Internal High setting enables the 83.3 µA source and directs it to the selected channel. Remember to re-select None before making any measurements.

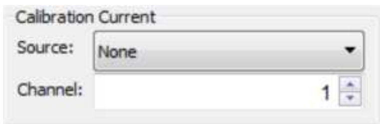


Figure 26. Calibration current control

The Clear Calibrations button resets all calibrations to nominal apart from the sensor calibration. Do not use this function unless you mean to.

9.5.4.1 Sensor calibration

You can define a sensor calibration gain and offset for each channel, to compensate variation in your sensor system. You enter the values directly after determining them using a suitable procedure. They are used by the PTC DiagnosticG2 for display and logging if you have the Compensated box checked, and by the monitor outputs if you select Sensor mode.

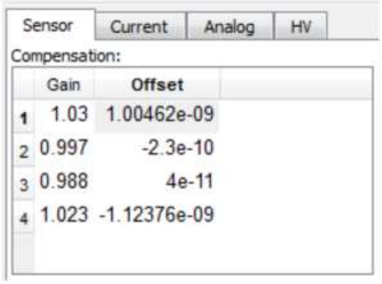


Figure 27. Sensor calibration sub-tab

9.5.4.2 Current calibration

The current calibration is responsible for converting binary values from the ADC to currents in amps. There is a gain and offset for each channel and each range. You can edit the values directly, although normally you will use the automatic calibration function. You can run the automatic calibration for all four channels or for any individual channel.

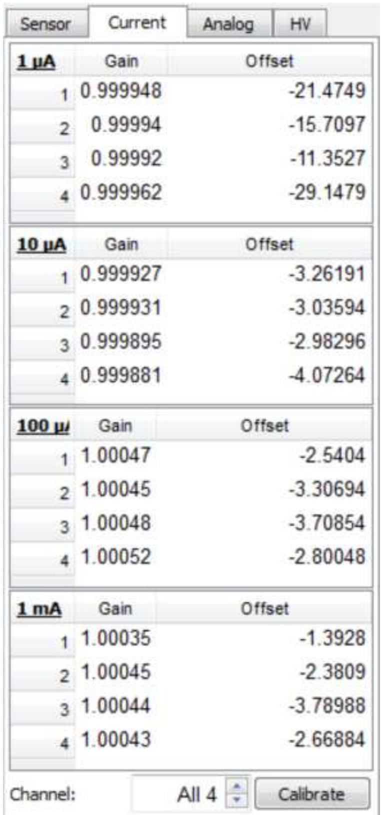


Figure 28. Current calibration sub-tab

9.5.4.3 Analogue calibration

The analogue inputs and outputs are factory calibrated; these values should be left unchanged.

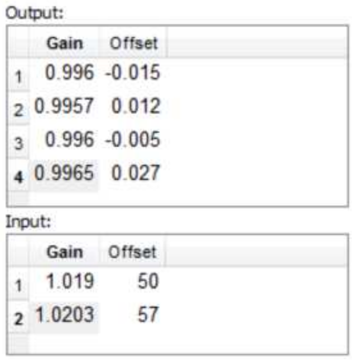


Figure 29. Analogue calibration sub-tab

9.5.4.4 HV calibration

The high voltage output calibration is factory set. The input calibration is done automatically by reference to the input calibration, and can also be entered directly. Ensure that the high voltage output is not being loaded by disconnecting any HV cable before changing the input calibration.

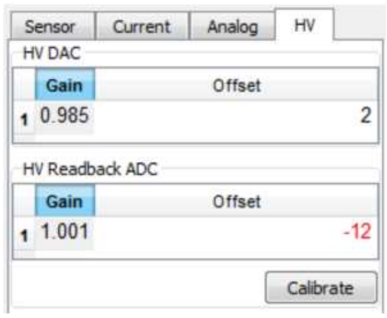


Figure 30. HV calibrations tab

9.5.5 Properties tab

9.5.5.1 Firmware

The Firmware section of Properties tab is where you can see the firmware versions you have loaded. There are three files (embedded Linux operating system, A60 realtime application, A60 FPGA).

Figure 31. Firmware versions

The individual firmware releases are combined as a compatible set into an overall firmware version. You can update the suite of versions when necessary by clicking the Update All Firmware button. The update is carried out via the Ethernet interface. See Section 25 for further information about firmware updates.

9.5.5.2 Communications

The Communication section of Properties tab is where you can see the Ethernet communication settings, and change them as needed.

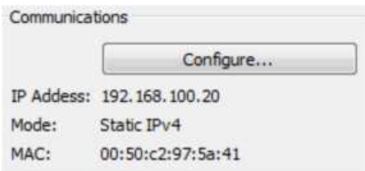


Figure 32. Communication settings

Pressing the Configure button allows you to change the communications identity of the F460, the IP address assignment mode, and the address and mask settings for static addressing. If you alter these parameters, you will need to re-discover the F460. If you change to a static address outside your local subnet, you will need to alter your network configuration to discover it again.

The Gateway and System Log address settings are for service and diagnostic purposes, and should be left at 0,0,0,0 unless you are instructed to change them.

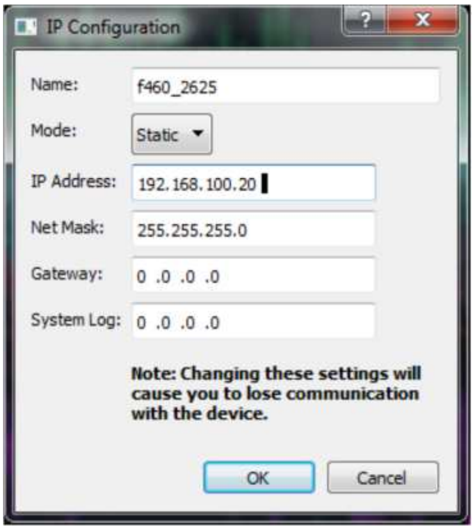


Figure 33. IP Configuration control

See Section 23 for more details on network configuration.

9.6 SCREEN LAYOUT – GRAPHIC DISPLAY

There are three ways of displaying incoming current and computed position data in a graphical way: as a rolling strip chart, as a scope display and as a histogram. Only the checked channels are displayed (but all channels are always measured and logged).

You can allow the vertical scale to adjust automatically, or select a percentage of full scale. The program will use the highest current range of the four channels as full scale. If your data is positive only, you allocate most of the vertical scale to positive currents with the Set the Y axis to start at 0 button ().

9.6.1 Strip display

Data from the selected channels, with the selected averaging, is plotted onto a rolling strip chart as it is acquired. The model for the display is a chart recorder. The horizontal axis is the time since acquisition started and the vertical (y) axis is the current.

Figure 34. Graphics display in strip mode with position display enabled

When the data you have acquired exceeds the horizontal axis capacity, a scroll bar appears below the graphic. This allows you to move backwards and forwards in the data that has been buffered by the PTC DiagnosticG2. You can do this while the acquisition is taking place, and after it has completed.

9.6.2 Scope display

The model for the scope mode display is a digital oscilloscope, and this mode is most useful when you are working in buffered / burst external triggering mode. If you have a data burst defined, then the screen is written with the contents of the burst when it completes, and then waits for the next burst. Thus if there is a repeating signal, such as a beam pulse, then you can obtain a display synchronized with the pulses. If there is no burst size defined, then the screen is refreshed after each data packet of 256 samples.

The graphic looks the same as the strip display.

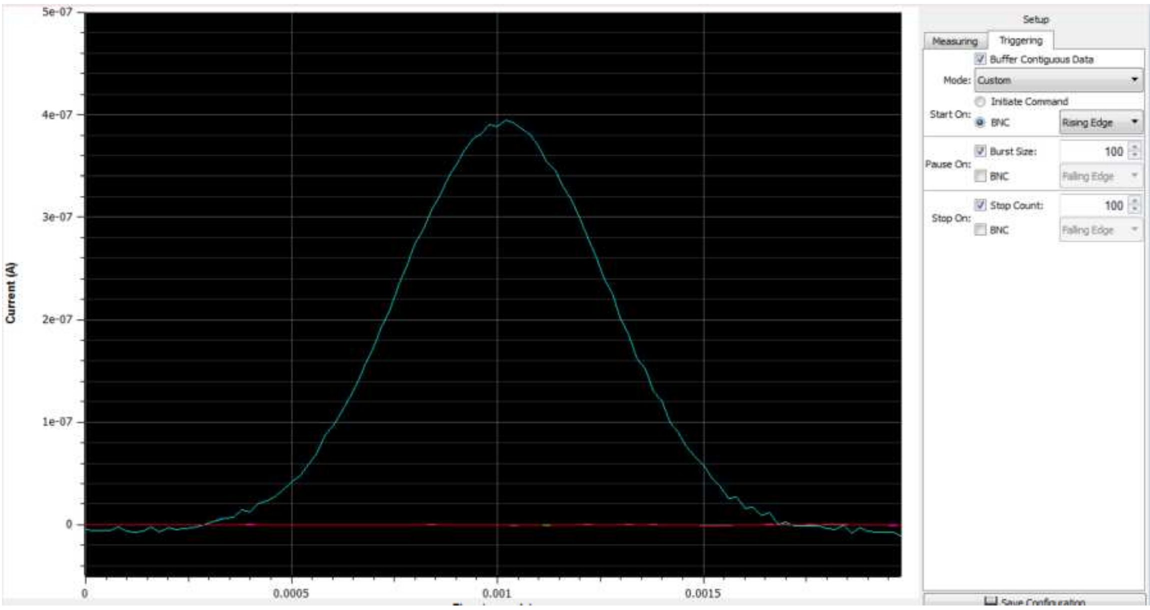


Figure 35. Scope mode capture of a 2 msec pulse captured with 20 μsec resolution

9.6.3 Histogram display

The signal each channel is displayed as a vertical bar. This mode emulates a graphic equalizer or ratemeter, and can be useful for instrument tuning.

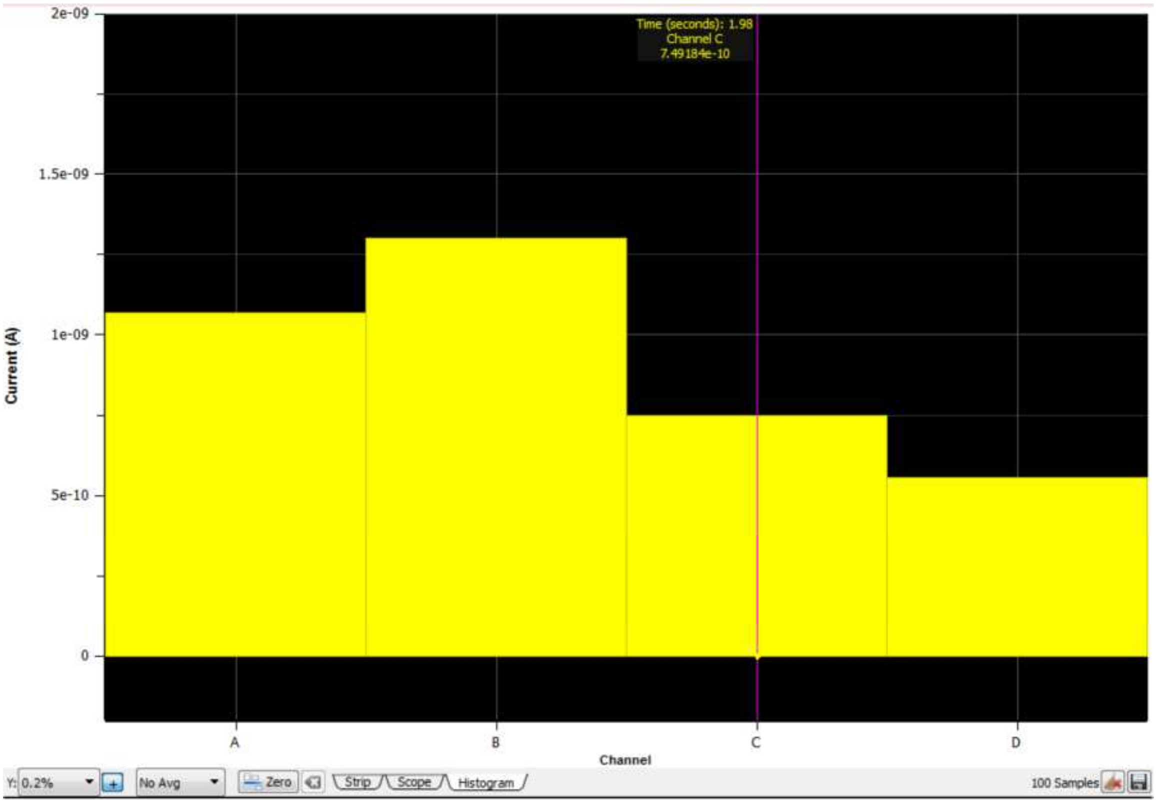


Figure 36. Histogram display

9.6.4 Cursor

Clicking in the graphic area in strip or histogram mode adds a moveable cursor, color-coded by channel, which gives the count at that time (strip display) or continuously in the channel (histogram).

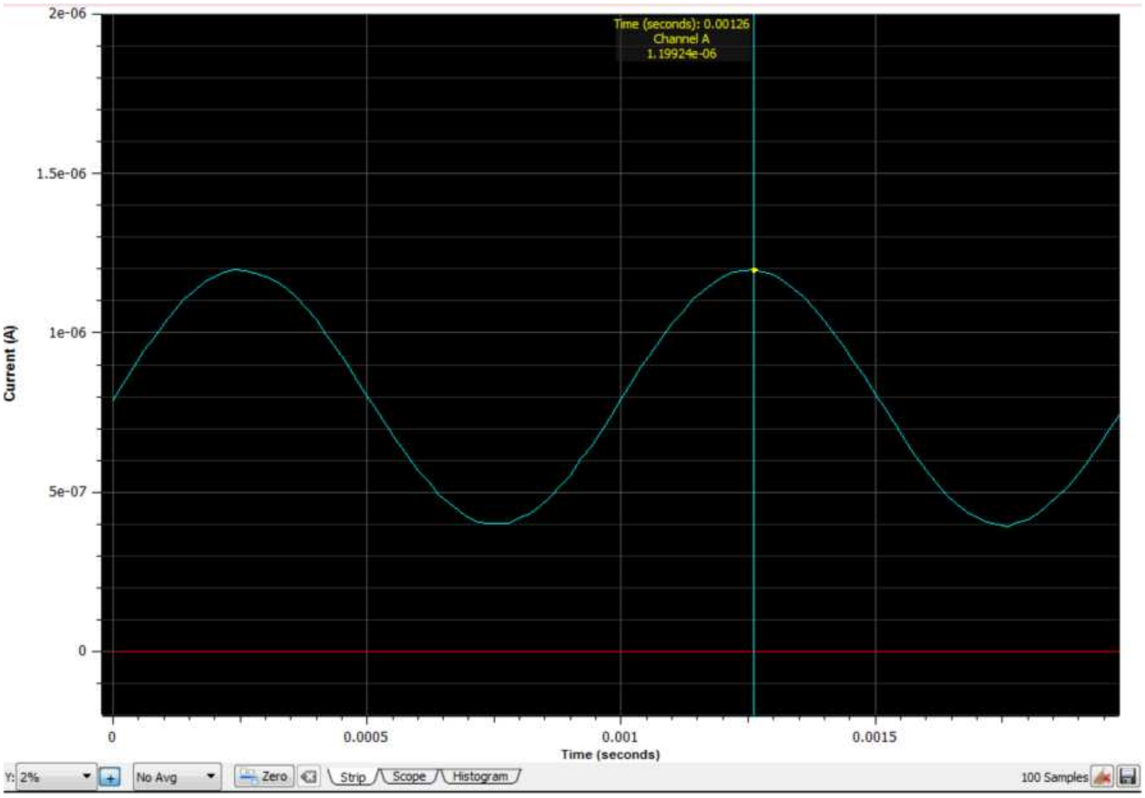


Figure 37. Strip chart data display showing cursor

9.6.5 Filtering and zero subtraction

You can low-pass filter the displayed data with "averaging" value A using the IIR algorithm

$Y_i = X_i/A + (1 - 1/A)Y_{i-1}$,

where Y_i is the latest output of the filter, Y_{i-1} is the prior output of the filter and X_i is the latest

reading from the F460. Note that the data is not altered, only the way it is displayed, so you can change between various amounts of filtering at any time. Figure 38 illustrates how the display of a square wave test signal is affected by the filtering setting. The noise reduces, at the expense of time resolution, in the inevitable way. This filtering is done in the PTC DiagnosticG2, and only affects the display. It does not affect the logged data.

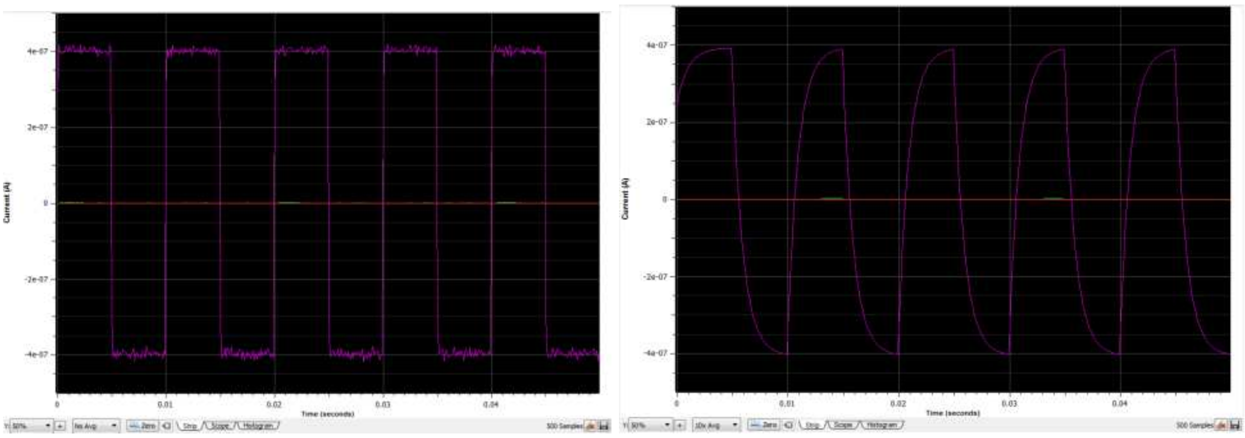


Figure 38. Increasing the low pass filtering of the displayed data

You can remove any zero offset present by setting the zero toggle (

). All displayed readings will have the readings at the time you set zero subtracted from them. If you are applying the zero correction to a completed acquisition you have already captured, then note that this means the final reading will be subtracted from data. As with the low pass filter, this is a display control for the PTC DiagnosticG2 only. If you have a real offset that you need to remove from the signals for a data collection run, then you should use the sensor compensation offsets.

9.7 DATA LOGGING

The PTCDiagnosticG2 software has a data buffer which can accumulate up to 100000 samples, at which point it wraps around and starts to overwrite the oldest values. Accumulation starts automatically when you click Initiate. You can capture the contents to a .csv format file at any time using the Save button. Pressing the Clear button clears the buffer and restarts the logging. The values logged are the timestamp (time since acquisition start), a trigger count which is a sequential integer from 0 to 255, the four input currents, the two analogue input values and the four analogue output values.

timestamp	triggercour	overrange	channel_1	channel_2	channel_3	channel_4	analog_in_	analog_in_	analog_out	analog_out	analog_out	analog_out_4
0	0	0	2.39E-09	1.28E-09	2.94E-07	-4.28E-10	-0.00066	-0.00032	0	0	0	0
0.0001	1	0	1.82E-09	8.26E-10	4.14E-07	-8.28E-10	-0.00014	0.000386	0	0	0	0
0.0002	2	0	1.94E-09	9.45E-10	4.03E-07	-5.59E-10	-2.49E-05	0.000423	0	0	0	0
0.0003	3	0	2.62E-09	1.52E-09	3.89E-07	-1.47E-10	1.24E-05	0.000336	0	0	0	0
0.0004	4	0	3.05E-09	1.76E-09	3.91E-07	-1.34E-11	-2.49E-05	0.000411	0	0	0	0
0.0005	5	0	2.71E-09	1.49E-09	3.94E-07	-2.64E-10	-1.24E-05	0.000262	0	0	0	0
0.0006	6	0	2.61E-09	1.20E-09	3.91E-07	-5.70E-10	-1.24E-05	0.000311	0	0	0	0
0.0007	7	0	3.44E-09	1.93E-09	3.99E-07	1.91E-11	-6.22E-05	0.000374	0	0	0	0

Figure 39. Example of logged data

Note that the logged data is the raw data: any low-pass filtering or zero offset removal does not affect the values you save.

10 F460 Circuit Overview

10.1 PHYSICAL CONFIGURATION

The F460 circuitry is arranged on two circuit boards:

- Main board. Circuitry is arranged on both sides of the board, with much of the analogue circuitry on the underside where it is screened from the digital signals.

- A60 processor board, including the Ethernet port, processor and memory.

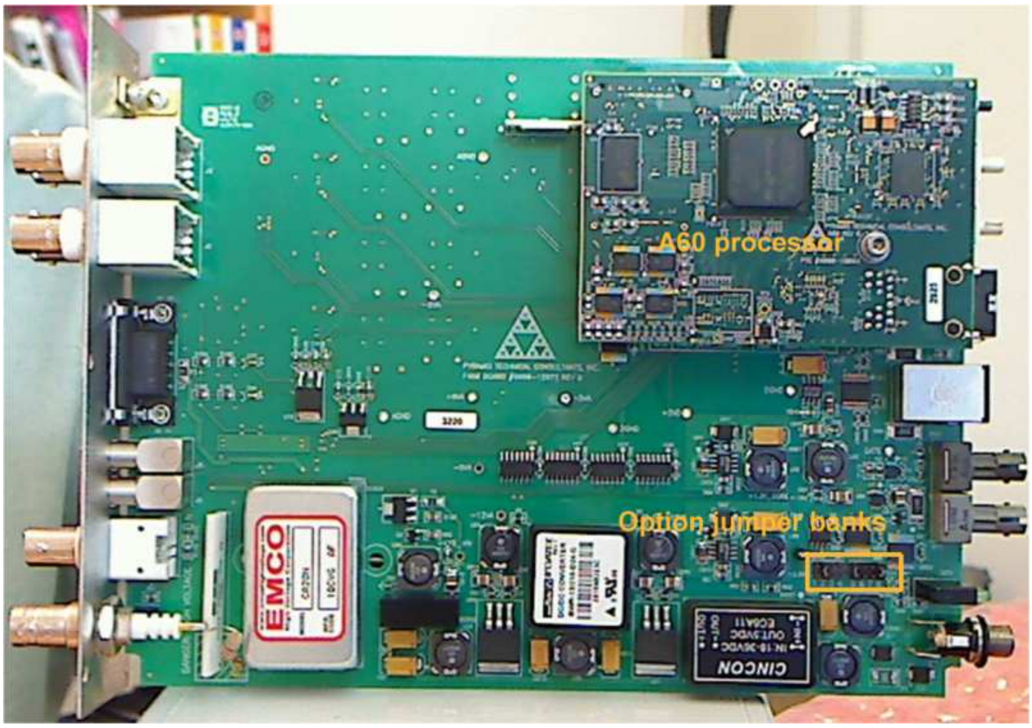


Figure 40. F460 physical layout showing option jumper location

The boards can be exchanged individually for service or upgrade. We recommend that such work is only done by a suitably qualified person.

10.2 FUNCTIONS

10.2.1 Current signals

Each input is protected by a spark gap, back to back clamping diodes and a 20 Ω high power series resistor. Each signal measurement channel comprises four current to voltage conversion circuits with different feedback resistors to give the four ranges. The required circuit is switched in under software control using semiconductor switches.

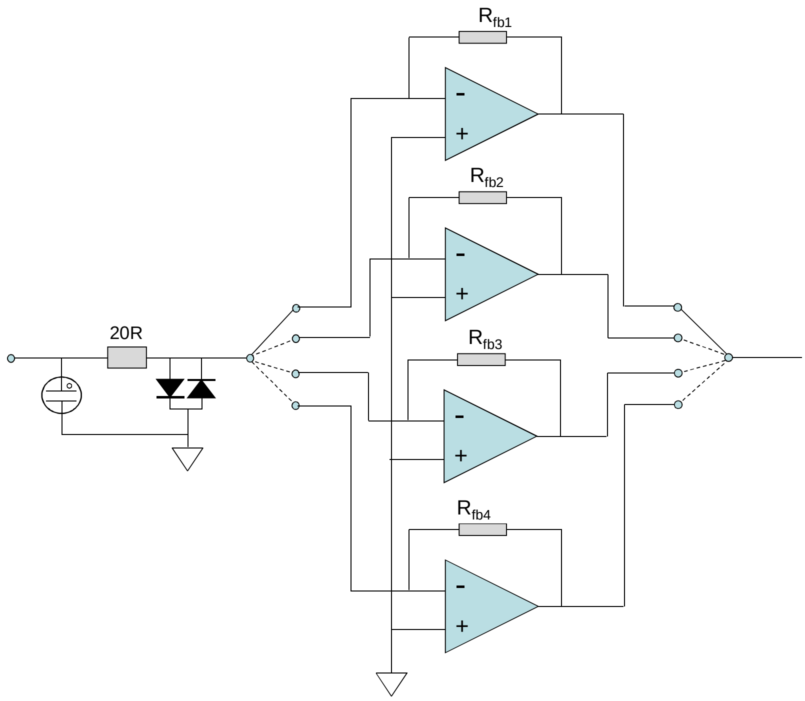


Figure 41. F460 inputs and converter stages

10.2.2 Analogue signals

The signals from these inputs circuits are low pass filtered with a four-pole Butterworth filter with -3dB at around 40 kHz, then fed to the 16 bit bipolar ADCs. The ADC is a multichannel fully parallel device which also reads the analogue inputs and the high voltage monitor.

The four analogue outputs are generated by 16 bit DACs and are buffered. Another DAC programs the high voltage power supply.

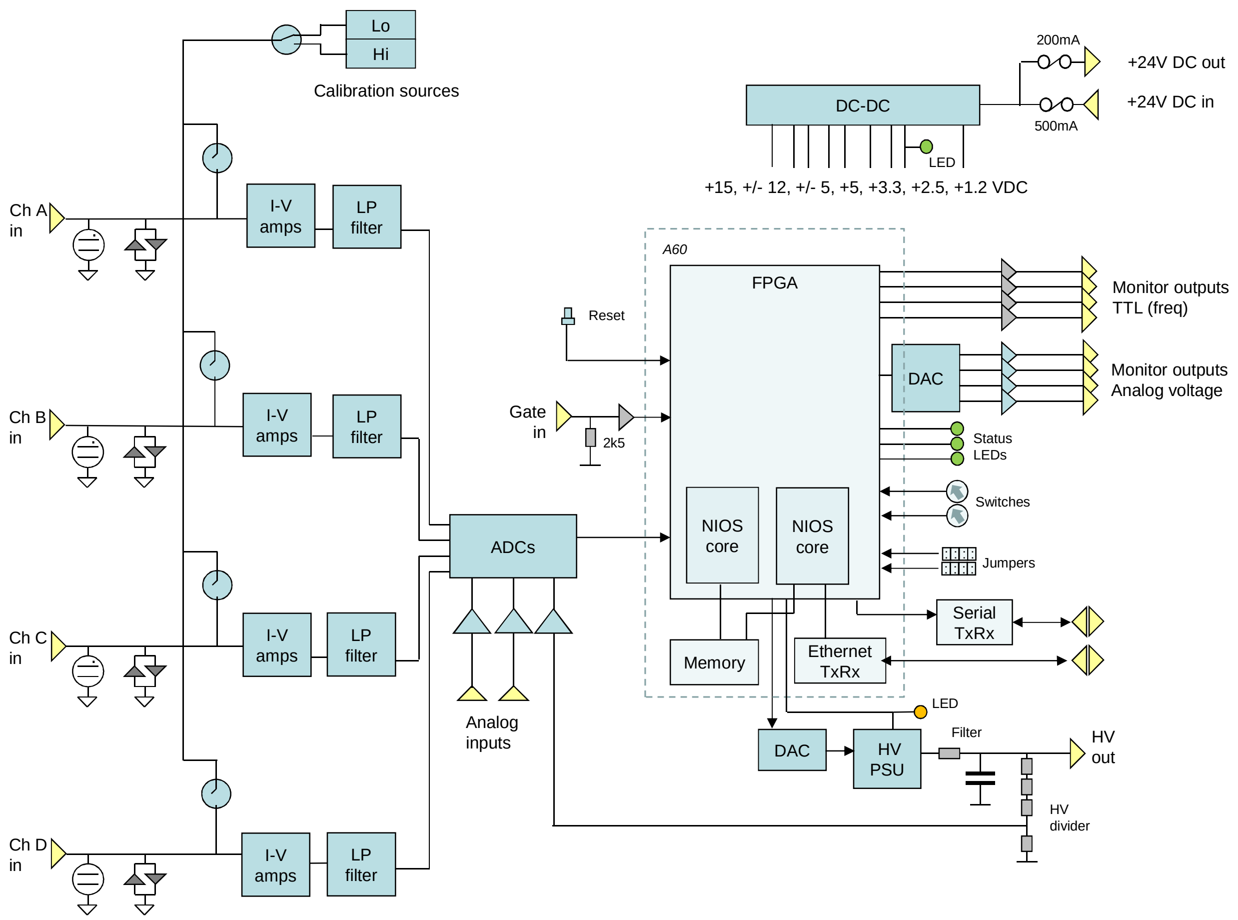


Figure 42. F460 overall block schematic

10.2.3 Calibration current switching

A matrix of switches allows the currents generated by the two precision calibration current sources to be routed to the required signal input under software control. The switching is controlled automatically during a calibration.

10.2.4 Digital signals

The digital lines are all buffered. The TTL gate input presents a 2.5 kΩ impedance to ground. The monitor outputs can drive a 50 Ω load at TTL levels.

10.2.5 High voltage

High voltage is generated by an EMCO module of the required rating. With a 2 kV module, the output is filtered by a 3 kHz RC filter with 33.2 kΩ series resistance. Lower series resistance is used for lower voltage modules. The filter is before the sampling voltage divider, so any voltage drop due to current drawn from the supply is visible in the readback. The worst case drop with a one watt 2 kV supply is 16.6 V at full current. The current draw is typically negligible when the load is an ionization chamber.

The voltage divider presents a 20 MΩ load to the supply, thus it will draw 0.1 mA from a 2 kV supply at full voltage.

10.2.6 A60

The A60 is the common processor platform for all Pyramid G2 devices. The A60 processor board contains a high performance FPGA (field-programmable gate array). Two NIOS processor cores are implemented in the FPGA, one handling the real-time F460 application written in Embedded C, and the other handling Ethernet communications running on uCLinux. High speed FPU instruction blocks are implemented in the FPGA to provide real time data processing. Additional RAM is provided for program execution and data buffering. The application processor communicates with devices on the main board using a serial bus.

The A60 sets the switches for I-V converter ranges and calibration current. The A60 handles communications on the channels on the fibre optic daughter board, and on the serial port. It reads the various switches and jumpers and sets the rear-panel status LEDs. It controls the enable line for the high voltage, which also drives the front panel indicator LED.

10.2.7 Power supplies

24 VDC input power enters via a 500 mA resettable fuse, and any device connected to the relevant pins of the analogue I/O connector. The 24 V input is protected against polarity reversal by a series diode, and from transients by series inductors and transorbs to chassis which limit excursions to 6 V (not shown on the block schematic). DC-DC converters and linear regulators generate the voltage rails required by the F460.

+24V	Power input. Not used directly by F460 circuits.
+15 V	High voltage module. Fused at 200 mA.
+/-12 V	I-V converter, other analogue amplifiers, filter and buffers, DAC reference (to 5V), filters
+5/- V Analog	ADC, ADC reference (to 4.096V), range switches, I-V amplifiers, calibration current select switches
+5V Digital	Calibration current sources, fibre transmitters & receivers, monitor output drivers
+3.3 V	A60, DAC, serial transceiver
+2.5 V	A60, status LEDs, switch and jumper read, calibration current select logic, general logic
+1.2 V	A60

11 High Voltage Supplies

11.1 SETTING THE HIGH VOLTAGE SUPPLIES

The F460 is available with a one-watt high voltage supply suitable for biasing ionization chambers. The voltage range can be specified at time of purchase from 200, 500, 1000, 2000V and 3000V with either polarity. The A60 processor reads internal jumpers on JB2 to detect the supply rating. Note that the supplies are not intended to deliver output voltage less than about 10% of their maximum rating.

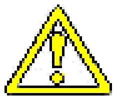
The front panel “Enabled” LED illuminates when the high voltage output is enabled. The set value can be adjusted at any time.

The outputs of the high voltage modules are filtered by an RC filter to reduce ripple and noise. The filter time constant is reduced for lower voltage HV supplies, to avoid excessive voltage drop at large current drains. You can see the actual output voltage because readback is taken from a voltage divider after the filter, directly on the HV output. The voltage divider places a fixed 20 MΩ load on the supply.

The following table gives the smallest value of external load resistance that the various one watt supply options can drive at full voltage, and the volts dropped across the filet series resistor at maximum current.

HV module	Current rating	Smallest load resistance	Filter time constant	Filter series resistor	Voltage drop across filter no load	Voltage drop across filter full load
+2000, -2000	0.5 mA	4.3 MΩ	110 µsec	33.2 kΩ	1 V	17 V
+1000, -1000	1.0 mA	4.3 MΩ	110 µsec	33.2 kΩ	2 V	34 V
+500, -500	2.0 mA	250 kΩ	16 µsec	4.7 kΩ	< 0.1 V	10 V
+200, -200	5.0 mA	40 kΩ	0	0	0	0

If the readback value differs from the setpoint by more than the expected drop across the filter resistor, you know that the output is either being overloaded by a low resistance to ground, or that it is being driven by another source of higher compliance. Be aware of how the high voltage readback calibration might affect this. We recommend that the calibration is done with no connection to the HV outputs. Thus only the no-load voltage drop across the filter is hidden by the calibration, and when you connect a load you should expect to see small reductions in the measured voltage, up to the maxima given in the table. The measured voltage is the actual voltage at the output connector.

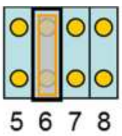
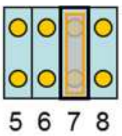
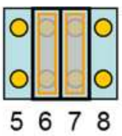
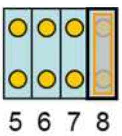
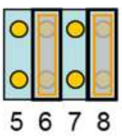


CAUTION

Do not connect an external power supply to the F460 external high voltage output that will drive the built-in supply away from the voltage it is trying to regulate, or you may cause damage to the F460.

11.2 CHANGING THE HIGH VOLTAGE SUPPLY RANGE AND POLARITY

The range and polarity of the high voltage supplies is fixed and must be specified at time of purchase. Units may be returned to the factory to change the high voltage modules if necessary. It not recommended that users change the high voltage supply modules in case of damage to the F460. The jumper settings are given here for reference only.

	+200 V
	+500 V
	+1000 V
	+2000 V
	+3000 V

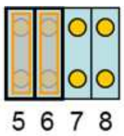
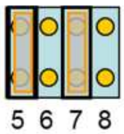
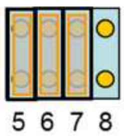
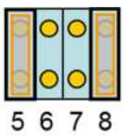
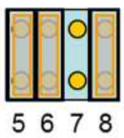
	-200 V
	-500 V
	-1000 V
	-2000 V
	-3000 V

Figure 43. High voltage jumper settings

No jumpers installed in JB2 is interpreted as no HV option fitted.

12 Samples, Logged Data and Averaging

12.1 READINGS AND LOGGED DATA

Each sample taken on the F460 comprises values for all the input signals. The frequency at which readings are generated is shown on the PTC DiagnosticG2 screen, and is determined by your selection of integration time.

Each reading comprises many data fields, which you can see in detail if you examine one of the csv log files. In summary, these fields are:

timestamp	Time in seconds when the reading was taken, starting from zero when the acquisition sequence started.
triggercount	A sequential number for the reading, mod 256. These numbers allow you to see very easily whether you have contiguous data.
overrange_1,2,3,4	Flags that get set if any of the four channels goes overrange on any individual conversion.
channel_1,2,3,4	Measured current values in amps for each of the four channels. The values reflect any sensor compensation if this is option is checked in the PTCDiagnostiocG2 Data tab. The values do not reflect any filtering (averaging) or zero subtraction selected for the PTC DiagnosticG2 graphics.
analog_in_1,2	Measured signal on the two general purpose analogue inputs.
analog_out_1,2,3,4	Settings of the four general purpose analogue outputs.

12.2 INTEGRATION TIME

The integration time is used to determine how many ADC readings are averaged to form each sample that the F460 reports. The ADC conversion rate is 250 kHz, thus for example if you have chosen 100 µsec integration, the readings will be the average of 25 individual ADC conversions.

The amount of averaging to use depends, as always, on how you wish to trade off noise against bandwidth. The longer your averaging period, the more you suppress random noise, but the more high frequency detail you lose. There is no risk of overrange when using long integration times, because the individual binary conversion values are summed digitally into a deep counter.

If you happen to know there is a dominant noise frequency in your system, say the line frequency, or the switching frequency of a power supply, then you can suppress this noise in the data if you set the integration period and averaging to match the noise period, or an integer multiple of the period. As an example, if you have noise at 400 Hz, then choosing 500 µsec integration and five conversions per sample will eliminate it, as will five conversions per sample at 1000 µsec, 100 conversions per sample at 100 µsec and so on.

Figure 44 shows how aliased 50 Hz noise can be eliminated matching the integration period to the noise frequency. The screen shot on the left was taken with 18 msec integration (56 Hz sampling) and the one on the left with 20 msec sampling (50 Hz).

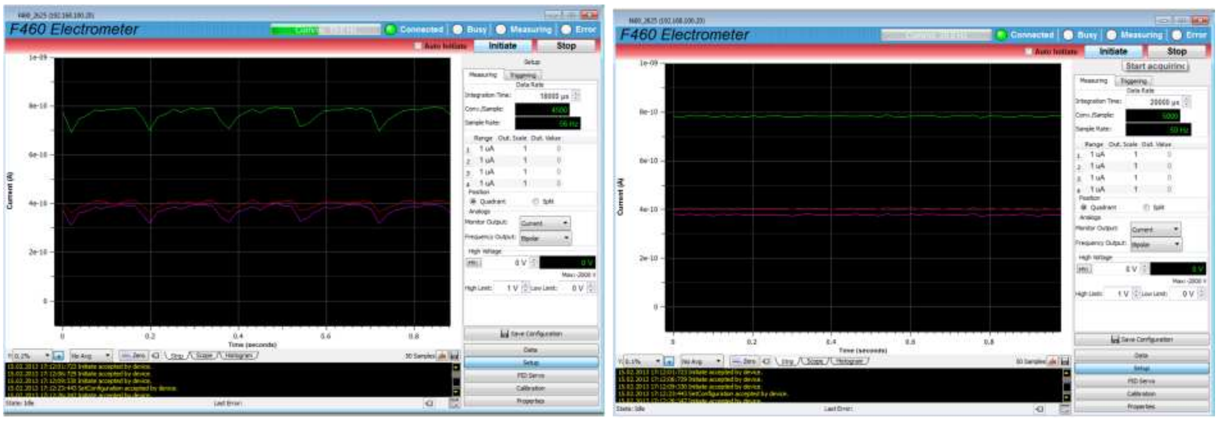


Figure 44. Eliminating noise by matching the noise frequency

If you have a short pulse of signal, then you may decide to try to time-resolve the pulse by using a burst of contiguous readings that cover the pulse duration. You can then integrate in time in off-line data post-processing to get the total charge. Alternatively you may not care about the time structure, but just want to know the total charge in the pulse. In that case you could choose an integration period that contains the whole pulse. The amount of data you need to handle is thereby reduced.

13 Triggers and Data Buffering

The F460 offers great flexibility for collecting data and triggering to synchronize with external events. The primary trigger modes are Internal and Custom. The other modes exposed in the PTC DiagnosticG2 software are provided mainly for backwards compatibility with other devices; they can all be achieved with particular custom configurations.

13.1 INTERNAL TRIGGER MODE

If you simply want to stream data continuously from the F460, then the Internal trigger mode achieves this. Don’t check the Burst Count or Stop Count boxes. When you press Initiate, the F460 will start streaming data to the host computer, and will continue until you abort the acquisition. The PTC DiagnosticG2 strip mode and histogram graphics will keep up with real time, shown under the strip mode plot as the time in seconds since the Initiate. The data rate is limited by communication rates over the Ethernet, however, and by the load on the host computer. Thus, beyond a particular data sampling rate, there will inevitably be missing readings in the record. The critical rate will generally be close to the Comms rate displayed on the PTC DiagnosticG2, normally about 20 Hz. When the sample rate is greater than the communications rate, the proportion of samples that you capture will be given by (communications rate)/(sample rate) to a good approximation. Whether you care about getting contiguous data will depend upon what you are trying to measure.

13.2 DATA BUFFERS

13.2.1 F460 internal buffer

The internal memory of the F460 allows you to acquire time contiguous data at very high rates. The maximum buffer size you can select is 65,535. However, because the buffer is implemented as a cascade of memory, and because data is always being sent up to the host computer during an acquisition, the amount of available buffering can appear to be variable. When you are acquiring data into the buffer at high rates, the PTC DiagnosticG2 display will generally lag behind real time, underscoring the fact that you are now taking data faster than it can be delivered to the host computer.

The F460 has demonstrated the capability to capture the full 65535 readings with 8 µsec integration on a lightly loaded network; this corresponds to a 0.52 second burst. At the shortest integration time of 4 µsec, over 8000 readings can be taken without buffer overflow. Actual performance will depend upon the details of your network.

Before taking any critical time-resolved data, you should test the available maximum number of samples under the expected worst-case loading of your network and host computer. We recommend that you also set a maximum number of readings (the Stop Count) when using the data buffers, to avoid arbitrary overwriting of the data.

13.2.2 PTC DiagnosticG2 buffer

The PTC DiagnosticG2 has its own circular data buffer with a maximum of 100,000 entries. This is independent of the F460 buffering. If you allow an acquisition to run longer than this, and recover the log file, you will see that the data has wrapped around. The oldest entries will be overwritten. If you wish to clear the buffer

You can clear the Diagnostic buffer at any time with the “Clear the data buffer button”

(). You can save the current buffer contents to a csv format file at any time using the “Save the data buffer to a file” button ().

13.3 EXTERNAL TRIGGERING

13.3.1 Custom triggering

The F460 will respond to edges on the gate input to start, pause and stop acquisitions. Using the Custom trigger mode allows you great flexibility in choosing when and how the F460 should take data, and how data taking should be synchronized with external events. The best way to understand the controls is to look at a schematic example.

13.3.2 Pre-defined trigger modes

The F460 provides a number of pre-defined trigger modes, primarily for backwards compatibility with other devices that support them. They can all be achieved by appropriate Custom trigger settings. In the following table, NBuf is the buffer size and NBst is the burst size. For every trigger mode you can force the F460 to the stopped state at any time by sending the Abort command.

Mode	Start	Pause	Stop	Notes
Internal	Internal	n/a	n/a	Acquisition will start immediately you send initiate, and continue indefinitely if unbuffered, or to the lesser of NBuf size and NBst if buffered.
Custom	User	User	User	Full user control over start, pause, resume and stop.
External Start	BNC	n/a	n/a	Acquisition will start when a valid trigger edge is seen after you send Initiate, and continue indefinitely if unbuffered. If buffered, it will do NBst readings on each valid trigger edge until it has acquired NBuf readings.
External StartStop	BNC	n/a	BNC	Acquisition will start when a valid trigger edge is seen after you send Initiate. If unbuffered, readings will continue until the opposite polarity trigger edge is seen. If buffered, it will stop on the lesser of NBst or Nbuf readings, or on the opposite polarity trigger edge, whichever comes first.
External StartHold	BNC	n/a	n/a	NBst is forced to a value of 1 in this mode. A single reading is taken for each valid trigger edge. This will continue indefinitely if unbuffered. If buffered, it will continue until NBuf is reached.
External Windowed	BNC	BNC	n/a	Acquisition will start when a valid trigger edge is seen after you send Initiate. They continue until either NBst is reached, or the opposite polarity edge is seen, at which point the acquisitions pause. They resume when the next trigger edge is seen. In unbuffered mode, this continues indefinitely. In buffered mode, it continues until NBuf is reached.

14 Position Calculation

The F460 implements the difference over sum position algorithm in real time using the incoming sensor compensated data. The exact shape of the function depends upon the size of the beam you are measuring, and the spacing between the sensitive elements (electrodes or diodes), but it is generally “S” shaped with very high position sensitivity when the beam is centered, falling off to zero sensitivity at the sides. Figure 45 shows the function (A-D)/(A+D) as a function of the position of a beam with Gaussian profile as it moves across a pair of electrodes, from D to A. The function value is always in the range -1 to +1. Near the center the slope is approximately constant, so you can assign a gradient in mm per unit over some limited range, and thus obtain a readout in physical units relative to the center of the electrodes. The broader the beam profile, the wider is the linear region, but the lower the sensitivity.

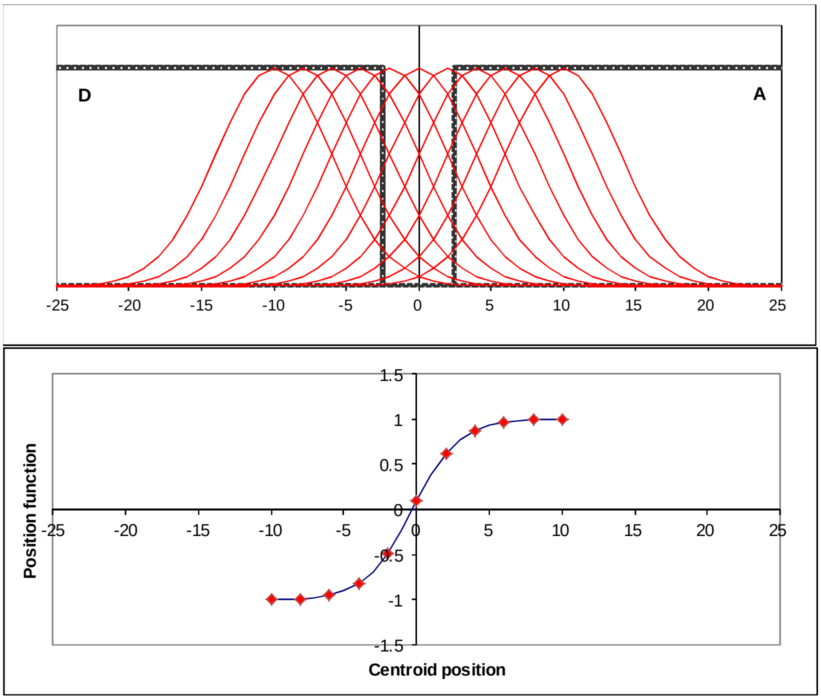
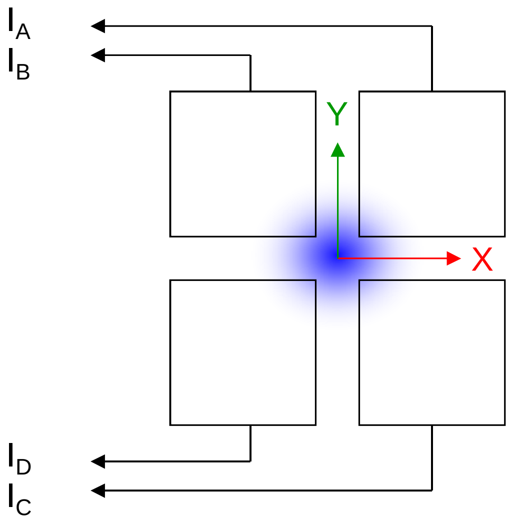


Figure 45. Position function shape

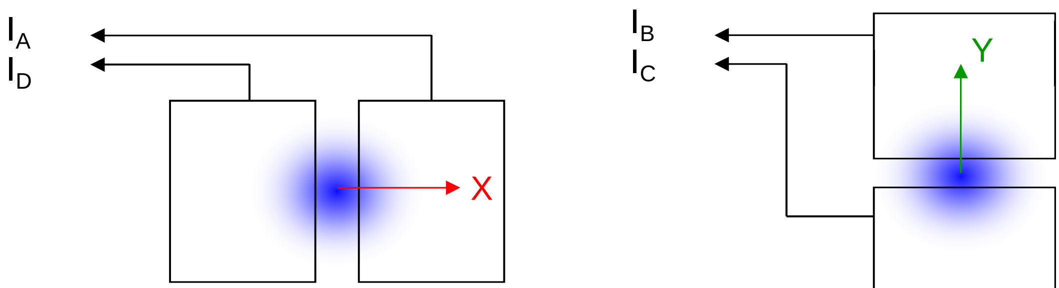
If the sensor is arranged in a quadrant pattern, then you can get the two orthogonal axes simultaneously. Alternatively, the F460 can read out two independent split (one-dimensional) sensors, which may or may not be orthogonal. To get the axis directions shown in Figures 44 and 45, you must connect the signals to the inputs in the order shown.



Y = ((A+B)-(C+D))/(A+B+C+D)

X = ((A+C)-(B+D))/(A+B+C+D)

Figure 46. Quadrant mode position calculation



X = (A-D)/(A+D)

Y = (B-C)/(B+C)

Figure 47. Split mode position calculation

15 Monitor Outputs

The monitor outputs provide a method to take data from the F460 without using the communications interface except for setting up the acquisition. The analogue voltage outputs emulate a direct signal from the outputs of the I-V converters. The range is -10V to +10V, and the outputs can drive 10 kΩ loads. The TTL outputs produce a 50% duty cycle square wave of controlled frequency to emulate a voltage to frequency converter connected to the outputs of the I-V converters. The TTL outputs can drive a 50 Ω load. The monitors provide a means to interface to legacy systems which have voltmeters or frequency counter inputs. Figure 48 shows example signals for 100 and 300 µA measured current on the 1 mA range.

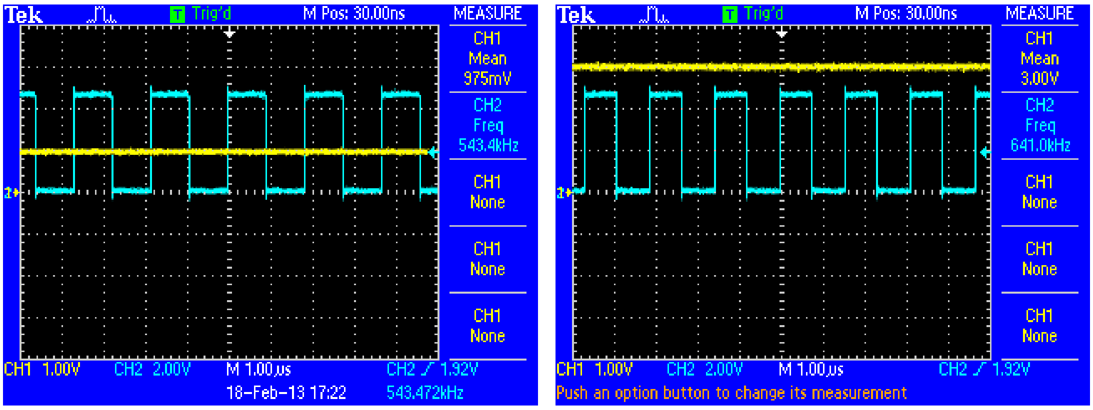


Figure 48. Analogue voltage (yellow trace) and TTL monitor (blue trace) outputs

The F460 provides a lot of flexibility about which signals you can direct to the monitor outputs, and which to the PTC DiagnosticG2 display. It is simplest to understand the options if we look at a map of the dataflow in the device.

15.1.1 F460 dataflow

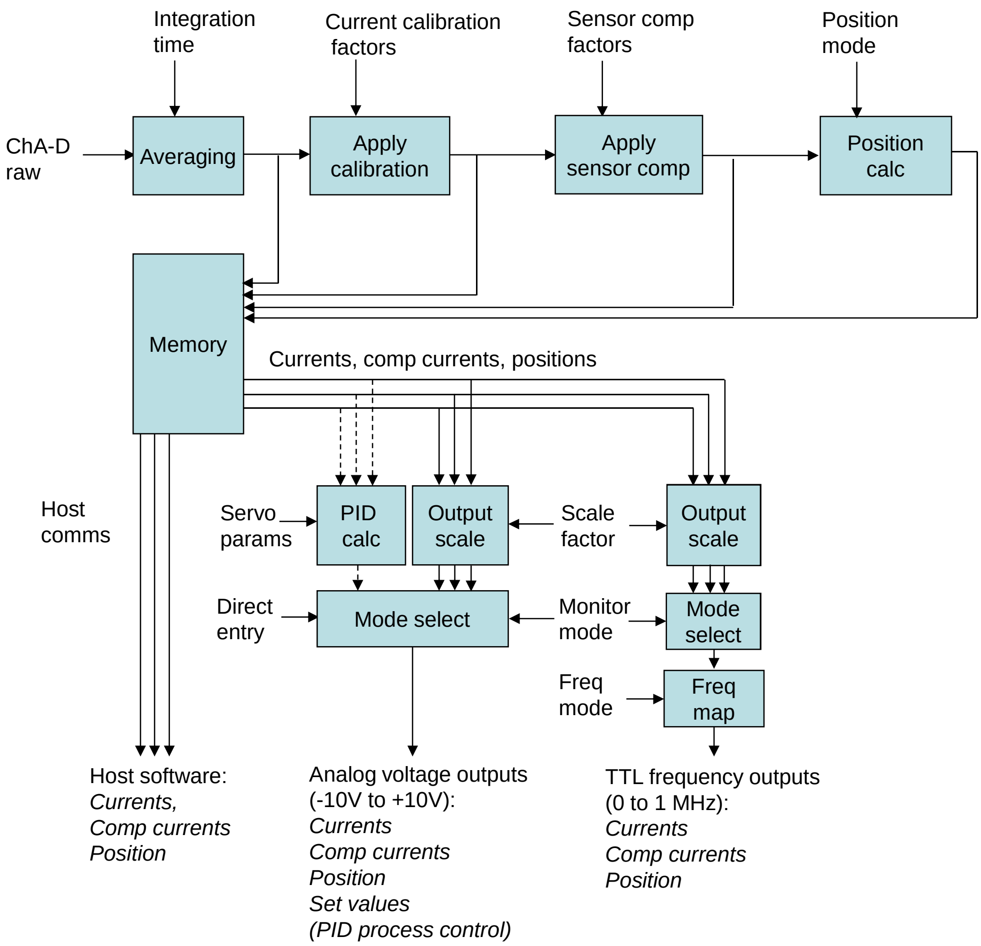


Figure 49. F460 dataflow

The raw binary values from the four channels are put through a sequence of calculations done in real time by the A60 FPGA. First they are accumulated (averaged) according to the integration period you have selected. Then the calibration is applied, for the selected range, to give floating point current readings in amps. The sensor compensation factors are applied. Finally the position algorithm is executed according to the mode you have selected (quadrant or split sensors). The results of all these stages of calculation are available in the F460 memory, and the host software system can access them as it requires.

The results are also available to the monitor outputs. The output scale gain factor allows you to adjust the mapping of the monitor output signals to best suit the device you are measuring then with, independent of any sensor compensation. The mode selection allows you to choose whether to map currents, sensor-compensated currents or position to the monitors. The TTL frequency output needs a further frequency mode selection to handle the fact that the F460 is a fully bipolar device, but we can’t have a negative frequency. The analogue outputs are used for the process control signals if the –S1 servo feature is installed and in use.

15.1.2 Mapping measured signals to monitor outputs

15.1.2.1 Analogue monitors

The analogue outputs can span -10 V to +10 V, so it is natural to map negative full scale to positive full scale current onto this range. The position function can range from -1.0 to +1.0, so this also maps naturally onto the analogue output range.

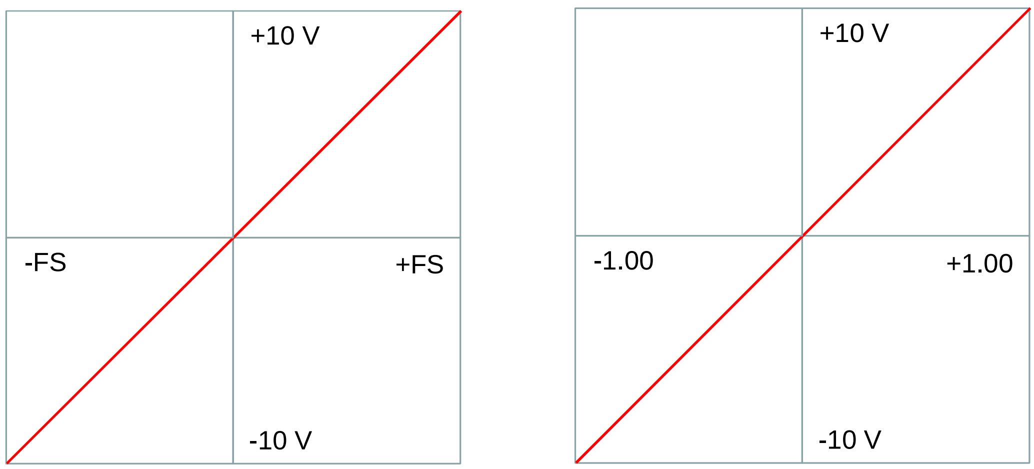


Figure 50. Default analogue monitor output mapping: current (left) and position (right)

You can control the gradient and span of the monitor output with the output scale value. This can be set in the range 0.001 to 2.0. In Figure 50, a value of 2.0 would map the full scale current range onto -5 V to +5 V. A value of 0.5 would map half of the full scale current range onto -10 V to +10 V.

The monitor output can be set to map the sensor-compensated readings. This allows you to remove the effects of any offsets or linear gain differentials in the sensor responses.

15.1.2.2 TTL frequency monitors

The overall response of the TTL frequency monitor outputs is the same as the analogue voltage, except that you must also choose how to handle the fact that the measured signal may be positive or negative, but only positive frequencies are possible. There are four options:

Bipolar	Zero current is mapped to half of the frequency range (500 kHz), with higher frequencies up to 1 MHz signifying positive currents or positions and lower frequencies down to 0 Hz signifying negative.
Positive	Only positive currents or positions are mapped onto the range 0 to 1 MHz.
Negative	Only negative currents or positions are mapped onto the range 0 to 1 MHz
Absolute	The absolute value of the current or position is mapped onto the range 0 to 1 MHz

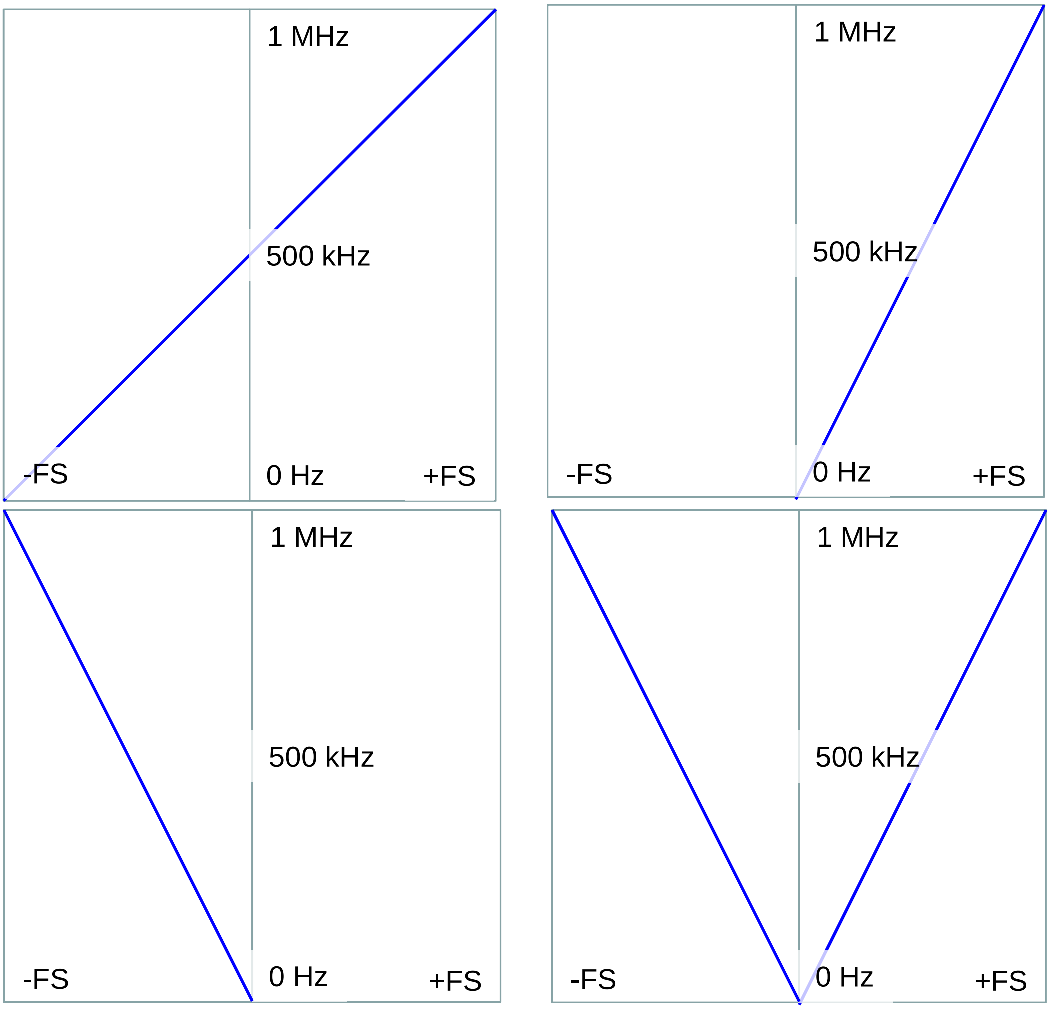


Figure 51. TTL frequency monitor options: bipolar, positive, negative absolute

Output scaling applies to the frequency in an analogous manner to the way it works for the analogue voltage monitors. The maximum frequency will actually run up to over 10 MHz when you use scale factors below 1. You can set sensor compensated currents, the same as for analogue voltage output.

16 Calibration

16.1 CURRENT CALIBRATION

The F460 is designed to produce very accurate current readings. The automated internal calibration process measures the background offset and the response to one of two very accurately known internal current sources. Multiple readings are taken and averaged with an integration period that nulls any 50 or 60 Hz noise. You should not have any connection to the inputs when doing a calibration. The resulting linear gain and offset values for each channel and each range are stored in non-volatile memory.

The calibration process does rely on the stability and absolute accuracy of the internal sources. These use high precision resistors with very small temperature coefficients. It is of course inherently impossible to detect any error in the internal sources by simply measuring with the F460 them after completing a calibration. You need to use an independent external source, which must itself have very good accuracy and stability. If your F460 is used for critical measurements where absolute accuracy is important, we recommend that you make such an external check once per year, or more frequently if local procedures dictate.

16.2 SENSOR CALIBRATION

The sensor calibration values should be entered directly by the user to compensate for offsets and channel to channel gain variation in the sensor system. Offsets are generally simple to establish by making measurements with no beam present. Gains require you to look at the response of each channel to a known increase in flux, which may be difficult to organize in a well-controlled manner. If the application is simply to sense when a beam is well-centered, having accurate gain compensation may not be so important. When you have a trial set of parameters, you can validate them for the position sensing application either by measuring a beam that is known to be well-centred, or by providing uniform flat-field irradiation. In either case you should see a position readout close to zero.

16.3 OTHER CALIBRATION

The calibrations of the analogue inputs and outputs, and the high voltage setpoint, are factory-set and should be left unchanged. If they do need to be corrected, the process is similar to sensor calibration. You will require an accurate voltmeter with at least 5½ digit resolution. Set the monitor mode to PID/Manual. Calibrate the zero offsets of the outputs until you read 0.00V with zero demand set. Then set 9.00 volts demand and set the gain so that the voltmeter reads this value. Check at -9.00 volts and iterate as necessary to minimize the error. Having calibrated the outputs, you can use a loopback connection to calibrate the inputs against the accurate outputs.

17 Connecting Slave Devices

The F460 implements a full fibre optic loop controller capability. You can connect up to 15 devices and access them via the F460 Ethernet port. To use a slave device, you simply connect it to the fibre-optic port on the F460 using suitable ST-terminated fibre-optic cable and run the normal Discover sequence in the PTC DiagnosticG2. The device will be shown as a slave of the F460, and you can open its window and control it in the normal way.

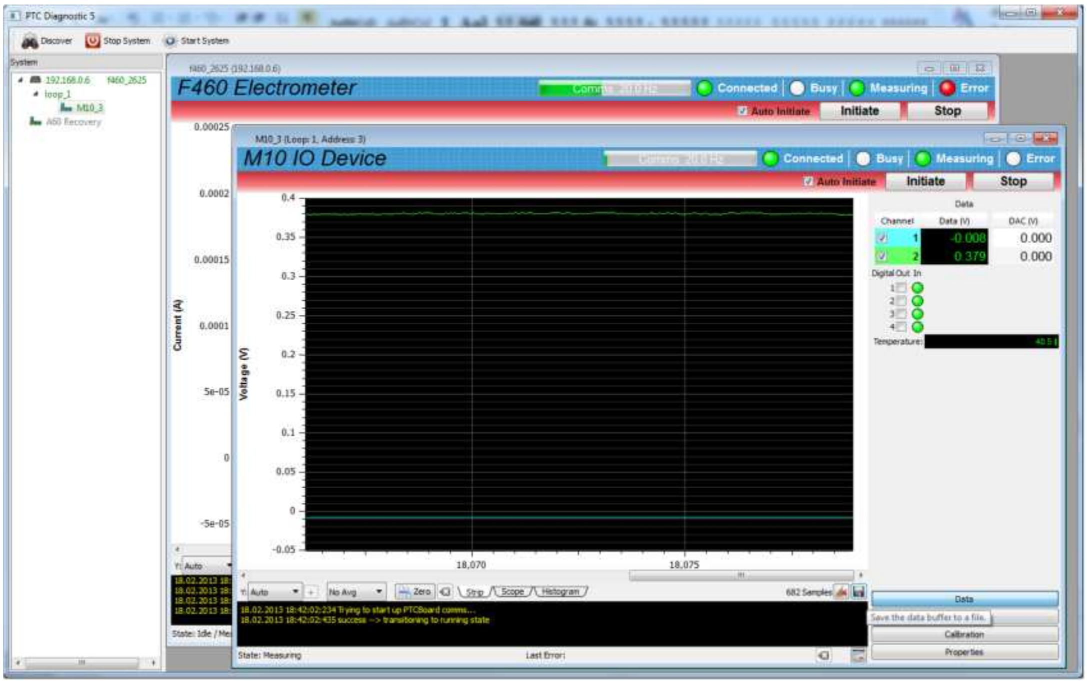


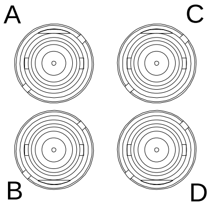
Figure 52. F460 with an M10 general purpose I/O device connected as a slave

The slave device simply passes its data through the F460. It is not constrained by the F460's acquisition settings.

18 Connectors

18.1 FRONT PANEL CONNECTORS

18.1.1 Signal inputs

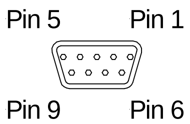


Four BNC coaxial, screens isolated from chassis.

Input A is synonymous with channel 1, or channel 0 (ASCII protocol).

18.1.2 Analogue input/output

Four Dsub 9 pin female.



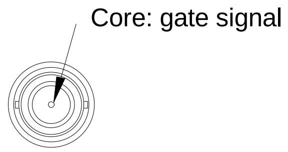
1	Analog ground	**6**	Analog out 1
2	Analog in 2	**7**	Analog in 1
3	+24 VDC out	**8**	0V
4	Analog out 2	**9**	Analog out 2
5	Analog out 4		

The 24 V output is fused at 200 mA, and is referenced to power supply 0V on pin 8.

Analog outputs 1 and 2 are used by the servo if this option is installed and enabled.

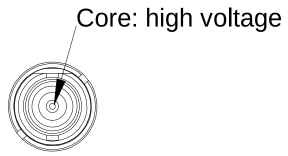
18.1.3 Gate input

One BNC female, screen isolated from chassis. To mate with standard BNC connector.



18.1.4 High voltage output

One SHV male, screen common with chassis. To mate with standard SHV connector.



18.2 REAR PANEL CONNECTORS

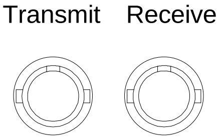
18.2.1 Ethernet communications

RJ-45 jack. To mate with standard RJ-45 plug.

Auto MDIX facility - cable can be direct or crossover type.

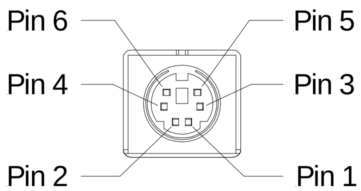
18.2.2 Fibre-optic communications

HFBR ST bayonets suitable for 1 mm plastic or 200 µm silica fibre. 664 nm (visible red) light.
Light casing = transmitter, dark casing = receiver.



18.2.3 RS-232/RS-485 communications

Six pin mini-DIN socket (PS/2 mouse/keyboard type).

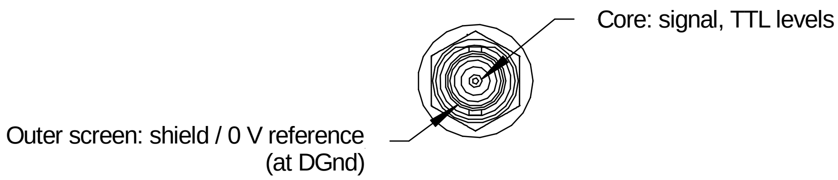


1	RS-232 Tx / RS-485 Tx-	**4**	n/c
2	RS-232 Rx / RS-485 Rx+	**5**	RS-485 Tx+
3	Gnd	**6**	RS-485 Rx-

The socket incorporates a sensor switch that allows the F460 to detect that a plug has been connected. When a connection is made, the RS-232 / RS-485 transceiver is active, and the communication mode is set by the mode switch.

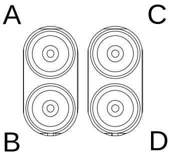
18.2.4 Gate input

BNC socket (female). To mate with standard signal BNC.



18.2.5 TTL (frequency) monitor outputs

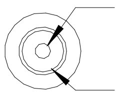
Four Lemo 00 coaxial.



Output A is synonymous with channel 1, or channel 0 (ASCII protocol).

18.2.6 Power input

2.1 mm threaded jack. To mate with Switchcraft S761K or equivalent



18.2.7 Ground lug

M3 threaded stud. To mate with M3 ring lug.

19 Controls and Indicators

19.1 CONTROLS

19.1.1 Reset button

Momentary push-button that forces a warm reset of the on-board processor. Forces the IP address to the default (192.168.100.20) if held on during boot up.

19.1.2 Address switch

16 position rotary switch setting device address for use when you have the F460 on a fibre optic loop. Choice of address is arbitrary, but each device in a fibre-optic loop system must have a unique address.

Setting	Function
0	(Reserved to loop controller)
1-15 (0x01 to 0x0F)	Available address settings.

If you are using the F460 as a loop controller, or using the Ethernet or serial interfaces, then the address switch has no function.

19.1.3 Mode switch

10 position rotary switch setting communications mode. This switch is read if a connection is made to the serial connector. The ASCII protocol is provided for ease of connection to existing systems and simple terminal programs.

Setting	Function
0	8 bit binary, 115 kbps, RS-232
1	8 bit binary, 57.6 kbps, RS-232
2	8 bit binary, 19.2 kbps, RS-232
3	ASCII, 115.2 kbps , RS-232
4	ASCII, 57.6 kbps , RS-232
5	ASCII, 19.2 kbps, RS-232
6	8 bit binary, 115 kbps, RS-485
7	8 bit binary, 57.6 kbps, RS-485
8	ASCII, 115.2 kbps , RS-485
9	ASCII, 57.6 kbps , RS-485

19.2 FRONT PANEL INDICATORS

19.2.1 HV on

Amber LED. Illuminated if the HV supply is enabled.

19.3 REAR PANEL INDICATORS

Four green LEDs.

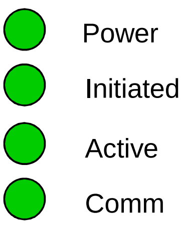


Figure 53. Status LEDs

19.3.1 Power

Green LED. 2.5 VDC power is present. This voltage rail is derived from the 5 VDC rail, which is in turn derived from the 24 VDC input.

19.3.2 Initiated

Green LED. Unit has been initiated and triggered to acquire data.

19.3.3 Active

Green LED. F460 processor has booted and is running normally.

19.3.4 Comm

Green LED. A host communication channel is active.

19.3.5 Power up sequence

On power-up, all LEDs light initially. The Initiated, Active and Comm LEDs then cycle in sequence while the F460 is booting. When booted, the Power and Active LEDs should be lit. If there is a host connection, the Comm LED will illuminate, and if the F460 has been commanded to acquire data, the Initiated LED will be lit.

19.3.6 RJ-45 indicators

Green LEDs incorporated in the Ethernet connector show that a connection has been established (left hand LED) and that messages are passing (right hand LED). These indicators are secondary, and difficult to see.

20 Communications Interfaces

The F460 is a member of the PSI G2 range of devices. The unit is provided with four hardware interfaces, RS-232, RS-485, fibre-optic and Ethernet. The RS-232 and RS-485 interfaces are intended for simple direct connection to PCs, with no other equipment necessary. The fibre-optic interface provides greater speed, excellent noise immunity, and allows multiple devices to be connected in a looped topology. It requires a fibre-optic adaptor or loop controller device to connect to the host computer. The fibre-optic interface is well-suited to large systems and experiments. The Ethernet interface is provided to allow direct connection to systems which are integrated using standard local area network hardware and protocols.

The F460 can support multiple clients, and in particular you can be connected via Ethernet and the serial port at the same time.

If the serial connector is attached, then the serial port becomes active, irrespective of any other connections. The baud rate, type of protocol and choice of RS-232 or RS-485 levels is made using the mode switch.

If the Ethernet connection is made then the Ethernet port becomes active. The mode switch and address switch have no function when using Ethernet communications. LEDs incorporated in the RJ-45 jack indicate activity on the port.

If neither serial nor Ethernet connections are made, then the fibre optic port is the active interface. The mode switch has no function. The address switch sets the fibre optic loop address.

20.1 RS-232 CONNECTION

A basic three-wire RS-232 connection is all that is required to communicate with the F460. The F460 uses a 6-pin mini-DIN connector. An adaptor to a 9-pin female DSub is available from Pyramid; a standard pin to pin male to female 9-pin DSub cable can them be used to connect to the PC. The cable length should not exceed about 5m, especially at the maximum baud rate. For longer serial cable runs you should use RS-485.

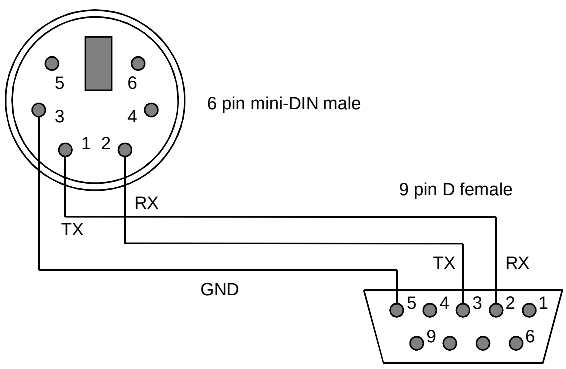


Figure 54. RS-232 cable F460 to PC

20.2 RS-485 CONNECTION EXAMPLES

RS-485 is used to extend a serial connection over a long distance. If you have a RS-232 serial port on the host PC, then an RS-232 to RS-485 converter is used at the host

PC end. The built-in RS-485 of the F460 allows a direct connection at its end. The F460 does not support multi-drop RS-485 connections.

A commonly-used converter is the MOXA TC100. The Moxa TCC-80 is a low-cost alternative for less critical applications. The converter should be configured for four wire (full duplex) RS-485 operation. The F460 provides parallel termination for transmit and receive. It is therefore optional whether you also terminate at the TC100 end, but there is no harm if you do. The recommended Dip switch setting for the TC100 is:

Sw1	Sw2	Sw3
OFF	ON	ON

The recommended Dip switch setting for the TCC-80 is:

Sw1	Sw2	Sw3
ON	OFF	ON

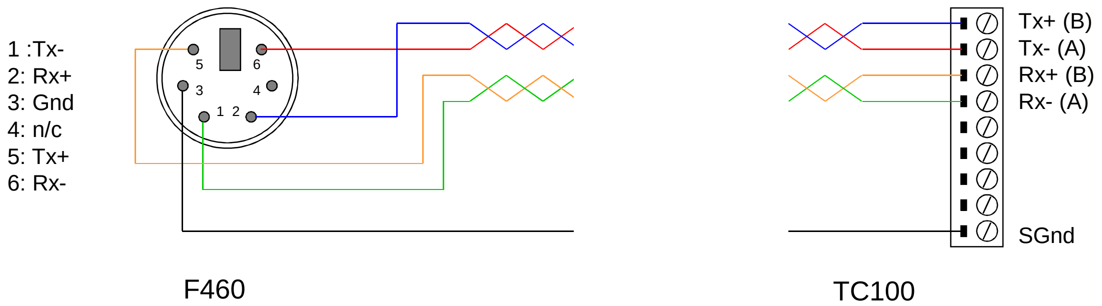


Figure 55. RS-485 cable F460 to TC100

In order to enable the RS-485 interface on the F460, you must have a physical connection to the serial port, and you must select one of the relevant modes (modes 6 through 9). If you have trouble getting the RS-485 connection to work, check carefully to ensure that you have all the transmit and receive lines connected as shown.

21 ASCII Communication

The F460 is a high performance device that will give you best performance with a dedicated host software application and high bandwidth communications interface. Nevertheless, there are numerous applications that do not require especially high performance, and connections to the F460 may be most convenient with a simple serial interface. The F460 supports a basic ASCII interface over RS-232 or RS-485. It supports some of the commands prescribed by Standard Commands for Programmable Instruments (SCPI) and IEEE 488.2, plus specific commands as required by the operation of the device.

All commands to the F460 should be terminated with LF only. All F460 responses are terminated with CR LF. The following table summarizes the non-printing codes used by the F460.

ASCII non-printing character	Symbol	Dec	Hex	Ctrl-char
Backspace	BS	8	0x08	Ctrl-H
Line feed	LF	10	0x0A	Ctrl-J
Carriage return	CR	13	0x0D	Ctrl-M

The commands are grouped with a hierarchical structure, with the levels separated by the colon character. For example:

CONFigure:PERiod 1e-2 // This command configures the integration period to have a length of 10 milliseconds.

Concatenating commands is not supported.

SCPI provides for a long and short form for each command. The short forms are indicated by the capitalized part of the command.

Commands which have a query equivalent for readback are marked with "(?)" in the following tables. Parameters are generally passed to the F460 with the set version of the command, but no parameters are passed for the query version. For example:

```
CONFigure:PERiod 1e-2    // set the integration period to 10 msec
CONFigure:PERiod?        // query the integration period
```

In the following tables,

{} denotes a required argument.

[] denotes an optional argument.

{}* denotes a required argument that may be included 1 or more times.

[]* denotes an optional argument that may be included 0 or more times.

21.1 IEEE 488.2 MANDATORY COMMANDS

Command	Command query available	Description
***CLS**	No	Clears the error state of the device. Does not clear the error/event queue.
***ESE**	Yes	Not supported
***ESR**	No	Not supported
***IDN?**	No	Identification Query. F460 returns manufacturer, model number, serial number, firmware version
***OPC**	Yes	Not supported
***RST**	No	Reset Command. Restart the device software and return to the *RST default conditions. .
***SRE**	Yes	Not supported
***STB?**	No	Not supported
***TST?**	No	Not supported
***WAI**	No	Not supported

21.2 IEEE 488.2 OPTIONAL COMMANDS

Command	Command query available	Description
***RCL**	No	Recall device configuration from flash
***SAV**	No	Save device configuration to flash

The settings covered by *RCL and *SAV are:

- CONFigure:PERiod
- CONFigure:RANge
- TRIGger:BUFfer
- TRIGger:BURst
- TRIGger:MODe
- TRIGger:SOURce
- TRIGger:POLarity

Settings saved using *SAV are automatically recalled when the device is turned on.

21.3 SCPI REQUIRED COMMANDS

Command structure				Command query available	Description
SYSTem	:ERRor	[:NEXT]?		No	Query the error/event queue for the next item and remove it from the queue. *ERR? is an alias for this command.
	:VERSion?			No	Query the SCPI standard version.
STATus	:DAC {Ch} {Val}			No	Not yet supported.

21.4 F460 SPECIFIC COMMANDS

Note that changing settings in the CONFigure or TRIGger subsystems ABORts the acquisition, requiring an INITiate.

Command structure				Command query available	Description
ABORt				No	Abort measurement
CALIBration	:COMPensation? {Ch}			No	Query external sensor compensation gain and offset factors for channel Ch. Channels are numbered 0 to 3 for A to D.
	:COMPensation {K1 O1 K2 O2 K3 O3 K4 O4}			No	Send external sensor compensation gain and offset factors for each channel. Compensation factors are automatically saved to flash.
	:GAIn? {Ch}			No	Query gain and offset for channel Ch for each of four ranges. Returns {GainChRnge1, OffsetChRnge1, …. GainChRnge4, OffsetChRnge4}
	:RANges?			No	Query the installed max current ranges in amps. Returns {Rnge1Max, …. Rnge4Max}
	:SOURce {Ch}			Yes	Enable (query) the internal calibration source to channel Ch. Selection of source current is automatic based on range in use. Disables the calibration current if Ch is not 0-3. Query may return a channel number even if the calibration current is off.

Command structure				Command query available	Description
CONFigure	:PERiod {Per}			Yes	Set (query) averaging period Per in seconds. Applies to all ranges. Value will be corrected for 1/ADCrate granularity (ie to the nearest 4 µsec).
	:PID	:MODe {Mode} [Mode]		Yes	Set (query) the PID mode for PID number 0 and optionally for PID number 1. Mode options for the servo process variable: 0: Custom (off or configured via RPC) 1: I1 2: I1+I2 3: I1-I2 4: I1/I2 5: X 6: Y 7: I1+I2+I3+I4 Modes 1-7 are for PID 257-263: Same as 1-7 for PROFile For PID number 1, modes 1-6 are available, but I3 and I4 are used instead of I1 and I2, respectively.
		:MODe? [PIDNo]		No	Query the PID mode for PID number PIDNo (0 if omitted).

Command structure				Command query available	Description
CONFigure	:PID	:RATE {Per}		Yes	Set (query) the servo period for to Per seconds (Per >= 5e-4, Per >= CONF:PERiod)
		:LIMit {limlo} {limhi}		Yes	Set (query) the control output analogue limits to limlo and limhi (in range -10V to +10V). Control output for PIDNo=0 is analogue output 1 Control output for PIDNo=1 is analogue output 2
		:ILOWlimit {SigI}		Yes	Set (query) the sum SigI amps of the input currents used to form the servo process variable for in the selected mode, below which the servo will be suspended.
		:KP {Prop}		Yes	Set (query) the proportional parameter to Prop.
		:KI {Int}		Yes	Set (query) the integral parameter to Int.
		:REFerence {value}		Yes	Set (query) reference value that is divided out from all sensor values for PID
		:PROFile	:LIMit {LimLo} {LimHi} {numPoints}	No	Set the low and high DAC limits in volts and the number of points in between for the automated profile sweep.
			:MAP {volts}*	No	Set a series of DAC points for the automated profile sweep.

Command structure				Command query available	Description
CONFigure	:RANge {Ch Rnge}			Yes	Set (query) current range for channel Ch to range Rnge. Rnge = 0 (highest) to 3 (lowest).
FETch	:ANAlogIn? [numSamples]			No	Returns analogue inputs for the numSamples most recent triggers for the two analogue inputs. Returns: numSamples *{averaging period, analn1, analn2, timestamp, trigger count, CR LF}. It is only possible to request multiple samples if TRIGger:BUFfer > 0. Otherwise, numSamples should be omitted. Returns up to 12 samples. If numSamples and TRIGger:BUFfer are greater than that, this command may be used multiple times to drain the buffer.

Command structure				Command query available	Description
FETch	:SENsor? [numSamples]			No	Returns compensated currents for the numSamples most recent triggers for the four current input channels. Returns: numSamples *{averaging period, curr1, curr2, curr3, curr4, timestamp, trigger count, CR LF}. It is only possible to request multiple samples if TRIGger:BUFfer > 0. Otherwise, numSamples should be omitted. Returns up to 12 samples. If numSamples and TRIGger:BUFfer are greater than that, this command may be used multiple times to drain the buffer.

Command structure				Command query available	Description
FETch	:CURrents? [numSamples]			No	Returns uncompensated currents for the numSamples most recent triggers for the four current input channels. Returns: numSamples *{averaging period, curr1, curr2, curr3, curr4, timestamp, trigger count, CR LF}. It is only possible to request multiple samples if TRIGger:BUFfer > 0. Otherwise, numSamples should be omitted. Returns up to 12 samples. If numSamples and TRIGger:BUFfer are greater than that, this command may be used multiple times to drain the buffer.
	:DIGital?			No	Read digital status bits. See following section for the meaning of the bits.
	:HIVOltage?			No	Read HV readback ADC. Returns {HV1}.

Command structure				Command query available	Description
FETch	:PID? [numSamples]			No	Fetch the running servo data. {PID Enabled, DAC initial V, DAC V, AnalogIn1 V, Measured process value f(I1,I2,I3,I4), Target process value f(I1,I2,I3,I4), Sum of (TargetProcessValue-ActualProcessValue), Following error (TargetProcessValue-ActualProcessValue),DAC low limit hit (0|1), DAC high limit hit (0|1), low current limit hit (0|1),timestamp,time-slice number, CR LF} May have additional fields if second PID is enabled. Returns up to 9 samples.
	:PROFile?			No	Returns numPoints * {DAC V, AnalogIn1 V, Measured Process Value, timestamp, time-slice number, CR LF} Returns up to 18 samples. Wraps around to the beginning after all samples are returned. The buffer is cleared by setting a new profile map or starting a new profile.
INITiate				No	Initiate data acquisition on valid trigger.

Command structure				Command query available	Description
OUTput	:ANAlog {Ch} {Value}			Yes	Set (query) the setting of analogue output Ch (0,1,2,3) to AnaValue volts, (+/-10V). Only available if OUTput:MONitor is set to mode 3 and PID is not being run for the particular output. Otherwise, these outputs are active as monitors.
	:FREQuency {0|1|2|3}			Yes	Set (query) mapping of TTL frequency monitor output. 0 = Bipolar 1 = Positive Only 2 = Negative Only 3 = Absolute
	:HIVOltage	:MAXvalue {HVm1}		Yes	Set (query) maximum allowable external high voltage setting HVm1 in volts. This is a software enforced limit.
		:SUPply?		No	Query maximum allowable external high voltage setting in volts, as determined by the installed HV module.
		:VOLts {HV1}		Yes	Set (query) the high voltage setting HV1 in volts. See FETch:HIVOltage? for readback value.

Command structure				Command query available	Description
OUTput	:HIVOltage	:ENable {0|1}		Yes	Enable/disable (query) the high voltage power supply.
	:MONitor {0|1|2|3}			No	Set (query) the position function that is performed internally by the F460, and thus the signals that are put out on the analogue voltage and frequency monitor outputs. 0 = no position calculation, monitor outputs map the input currents 1 = no position calculation, monitor outputs map the compensated input currents 2 = monitor outputs A and B map X and Y positions based on the currently set calculation 3 = monitor outputs are controlled directly or by PID
PID	:SERVo {0|1}			Yes	Set (query) servo state 0 = disable 1 = enable

Command structure				Command query available	Description
PID	:PROFile {0|1}			No	Set (query) automatic profile state 0 = disable 1 = enable The profile will remain enabled until either turned off by this command, or when all data points have been collected by the device and the profile is completed.
SYSTem	:COMMunication	:TIMEout		Yes	Set (query) timeout in seconds. 0 = timeout disabled. F460 will turn HV off if no valid message is received in the timeout period.
		:IPMODE {DHCP|Static}		Yes	Set (query) the IP address setting mode. NOTE: Changing this setting may cause loss of communication with the device for several seconds.
		:IPaddress {x.x.x.x}		Yes	Set (query) the IP address.
		:NETmask {x.x.x.x}		Yes	Set (query) the subnet mask.
		:GATEway {x.x.x.x}		No	Set (query) the default gateway if IPMODE is Static.
		:LOGipaddress {x.x.x.x}		Yes	Set (query) the system log IP address

Command structure				Command query available	Description
SYSTem	:SERIALnumber?			No	Query the serial number of the F460.
	:ERRor	:COUNt?		No	Query the error/event queue for the number of unread items. As errors and events may occur at any time, more items may be present in the queue at the time it is actually read.
TRIGger	:BUFfer {size}			Yes	Set (query) the F460 on-board data buffer size (stop count). Setting a buffer size > 0 enables buffered mode.
	:BURst {count}			Yes	Set (query) the number of samples acquired in a burst (i.e. before a pause). This is 1 in EXTERNAL_START_HOLD mode
	:MODE {mode}			Yes	Set (query) the trigger mode to mode. The options are: CUSTom, INTernal, EXTERNAL_START, EXTERNAL_START_STOP, EXTERNAL_START_HOLD, EXTERNAL_WINDOWED
	:POLarity {0|1}			Yes	Set (query) external gate polarity (external trigger only). 0 = rising edge, 1 = falling edge (invert BNC trigger)

Command structure				Command query available	Description
TRIGger	:SOURce	:STARt {INTernal|BNC}		Yes	Set (query) the start trigger source. Used in CUSTom, EXTERNAL_START, EXTERNAL_STARTSTOP, EXTERNAL_START_HOLD, and EXTERNAL_WINDOWED modes.
		:STOP {INTernal|BNC}		Yes	Set (query) the stop trigger source. Used in CUSTom and EXTERNAL_STARTSTOP modes.
		:PAUse {INTernal|BNC}		Yes	Set (query) the pause/burst trigger source. Used in CUSTom and EXTERNAL_WINDOWED modes.

21.5 DIGITAL STATUS BITS

0	Connected
1	Pending/Busy
2	Error
3	Reserved
4	Output changed (NOT SUPPORTED)
5	Reserved
6	Urgent device error (NOT SUPPORTED)
7	Reserved
8	Updating firmware
9	Starting up
10-15	Reserved
16	Acquisition Running (Measuring)
17	Acquisition Paused (Waiting for trigger)
18	Acquisition Stopped
23	BNC gate toggling (Triggering)

21.6 USING PUTTY TO TEST THE SERIAL ASCII CONNECTION

Microsoft Windows no longer includes a terminal emulator that you can use to test the ASCII communications. Hyperterminal may be transferred from an unused prior Windows version by copying the files hypertrm.exe and hypertrm.dll. Various public domain programs are also available to perform this task. Pyramid has tested PuTTY and Realterm with the F460. The following screenshots show the configuration of PuTTY with 115kbps baud rate.

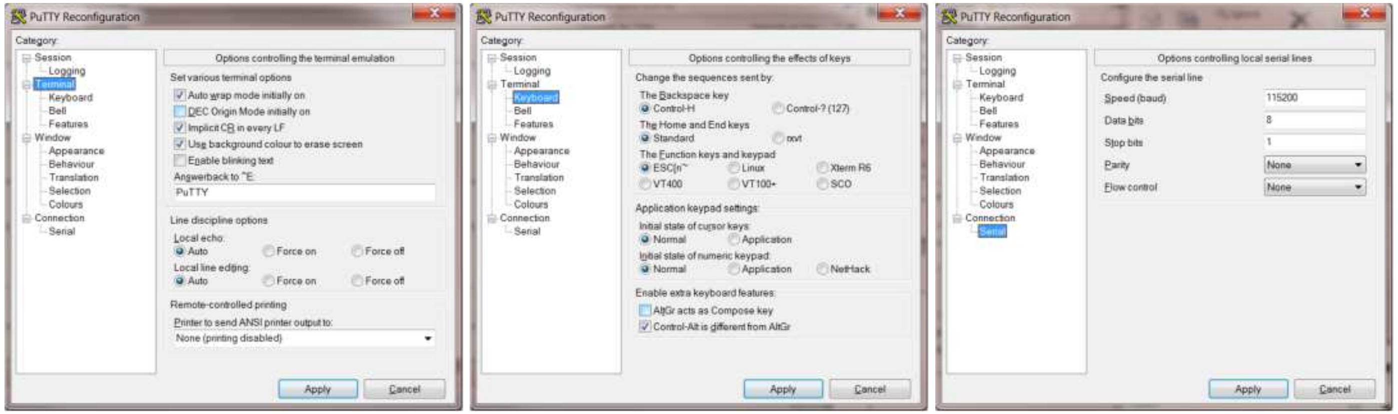


Figure 56. Setup of PuTTY for ASCII serial communication with the F460

You can be connected to the F460 via ASCII serial and the PTC DiagnosticG2 via Ethernet at the same time. Some behavior may be unusual, so this is only recommended for fault finding, not routine measurement.

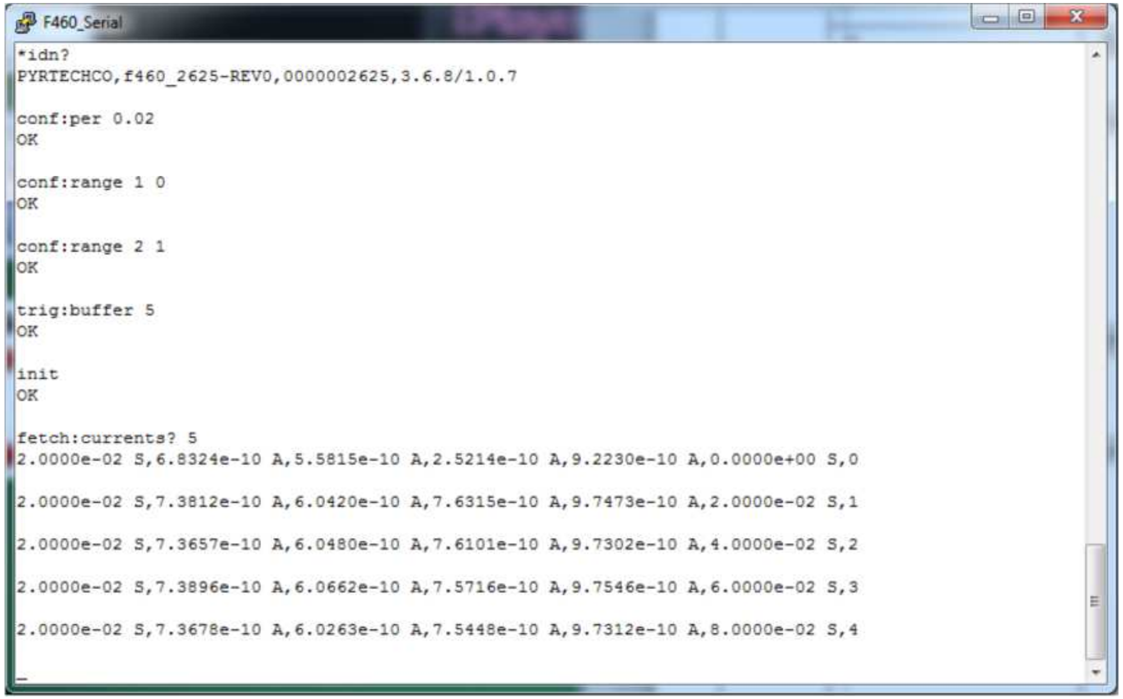


Figure 57. Example terminal session us PuTTY

22 Creating a Host Software Application

Pyramid Technical Consultants, Inc. provides a full application programming interface for the F460, based upon a C++ library. Full details are available upon request.

23 Using the F460 on a Network

23.1 NETWORK CONFIGURATIONS

The F460 uses TCP/IP and UDP communication over standard local area network hardware. Addressing is using the IP4 standard, and it supports static and dynamic (DHCP) address assignment. The device can be configured via the PTC DiagnosticG2, via the serial interface, or by your own host software using the appropriate procedure calls.

Most control and data acquisition systems are set up with fixed addresses assigned by the network administrator. It is also typical to isolate such networks from the internet to prevent unauthorized access, and to allow operation without firewalls which can disrupt communications.

In order for the host computer and the F460 to communicate, they must be within the same subnet. It is typical to limit a local network to 256 addresses by setting the IP4 subnet mask to 255.255.255.0. Then the F460 and the host must have the first three bytes of their addresses common, and must differ in the last byte. For example, the host could be 192.168.100.11 and the F460 192.168.100.20. The last byte must also not conflict with any other devices on the same subnet. Addresses with last byte 0 and 255 are reserved for special functions in TCP/IP.

Note that if you are communicating with the F460 using Ethernet and you change its IP address, then your communication channel immediately becomes invalid. You need to rediscover the device if using the PTC DiagnosticG2, or otherwise change your host software setup as needed. If you have moved the F460 into a different subnet, for example by setting it to a static address of 192.168.1.20 in the prior example, then will also need to the host PC's IP address into the same subnet before you can reconnect.

The simple static IP arrangement allows you to connect using a direct cable connection as shown in Figure 58, or via a network switch, as shown in Figure 59.

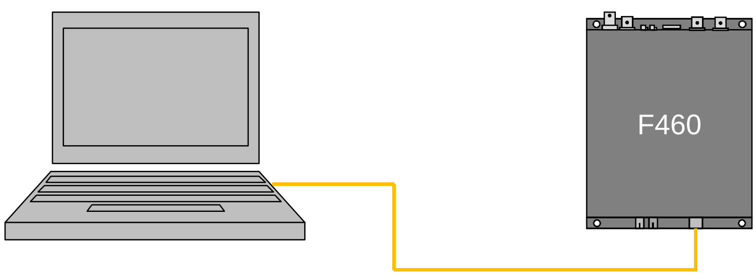


Figure 58. Direct connection

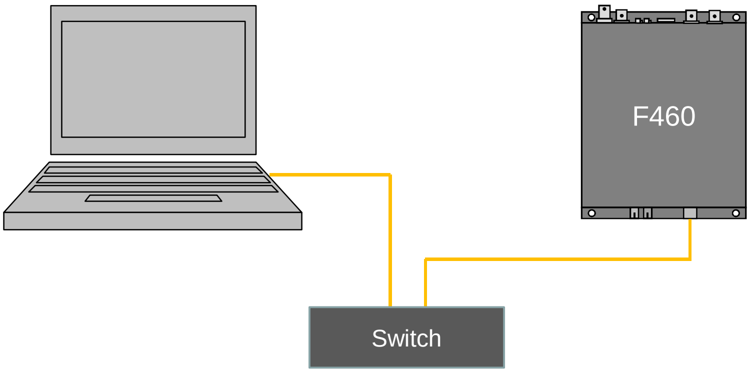


Figure 59. Connection via switch

Static addressing will also work if the network includes a router, but this arrangement also allows dynamic address assignment by the router. If your host software expects devices to be at specific addresses, this is not appropriate, but it can be helpful for initial testing and for fluid setups. The router will ensure that there are no address conflicts. The Discover utility in the PTC DIagnosticG2 makes the use of DHCP-assigned addresses practical.

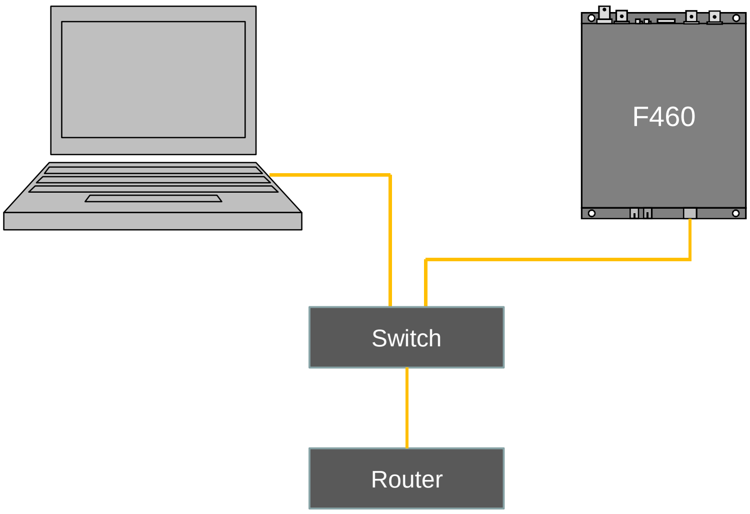


Figure 60. Network including router

You may wish to define the address of this router, or some other access point on the network, as the default gateway, if you want the F460 to be accessible from another network. This is optional.

23.2 RECOVERY FROM AN UNKNOWN IP ADDRESS

There are two ways to restore the F460 to a known IP address.

23.2.1 Reset at boot time

If you keep the reset button depressed for the first five seconds while the F460 is powering up, it will return to its default IP setting, which is a static address of 192.168.100.20.

23.2.2 Using the serial port

You can query and set the F460 network configuration via the serial port. The sample session in Figure 61 shows interrogation of the settings, and then a command to change from DHCP to static address assignment.

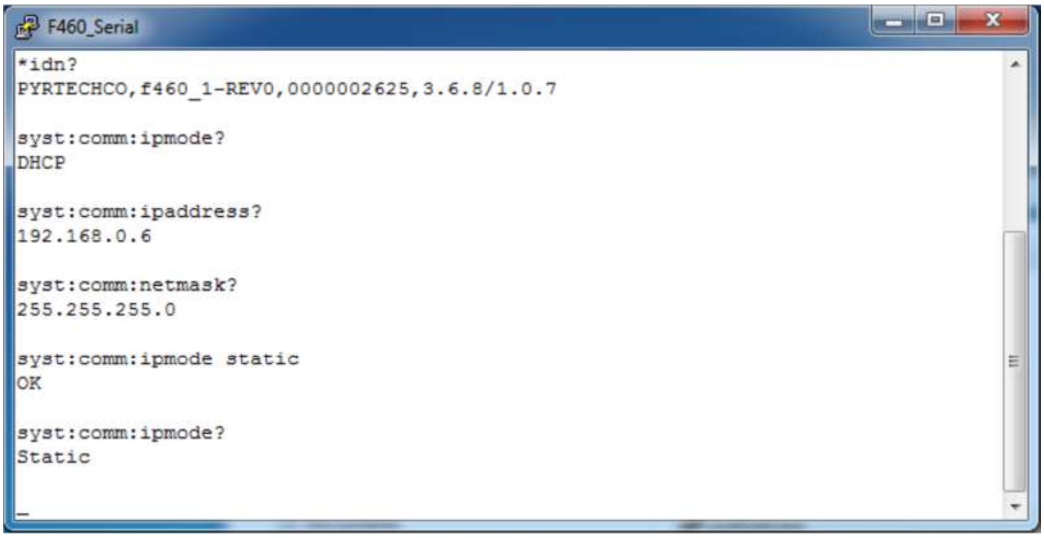


Figure 61. Terminal session to interrogate and set IP configuration

23.3 SYSTEM LOG ADDRESS

The system log address is the IP address of a syslog server that can log status and error messages from the F460, for diagnostic purposes. You should leave this set to 0.0.0.0 unless you are doing diagnostic investigations directed by Pyramid Technical Consultants.

24 S1 Servo Option

The F460 with the –S1 servo option gives you the ability to control some process based upon the current readings. The archetypal process is stabilization of an X-ray double crystal monochromator (DCM) output, where ionization chambers or photodiodes are used to measure the X-ray flux, and variations can be compensated by driving the crystal cage piezo motor. However any process which can be controlled by an analogue voltage and monitored by small currents can be handled.

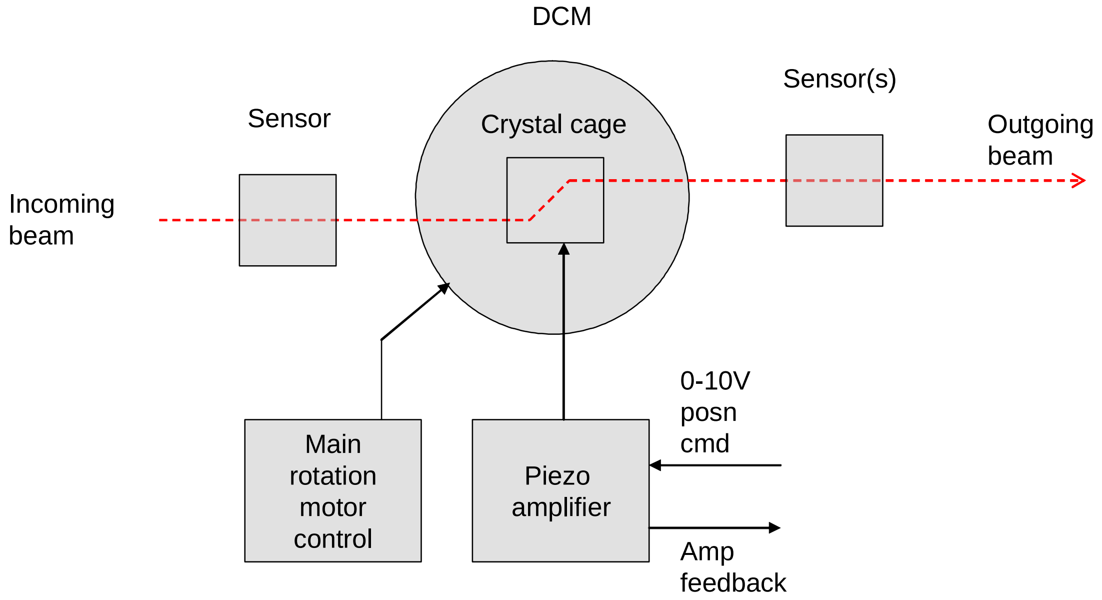


Figure 62. Schematic DCM installation

The current servo implementation in the F460-S1 is a PI controller which maintains the process variable value that existed at the moment the controller was activated, by adjusting the process control output (analog out 1 voltage or analogue out 2 voltage). You can define the process variable as any arithmetic combination of the inputs, for example:

A	The servo will attempt to stabilize the value of channel A
SumABCD	The servo will attempt the stabilize the value of the sum of the channels
DiffAB	The servo will attempt to stabilize the difference B-A
QuotientBA	The servo will attempt to stabilize the ratio B/A
Quadrant	The servo will attempt to stabilize the position function ((A+D)-(B+C))/(A+B+C+D)

The PI servo implements the algorithm

$$DAC_{out} = DAC_{initial} + k_{\mathrm{Prop}}.err + k_{Integral}.\sum err$$

where DAC is the output analogue voltage, err is the difference between the process value target and the latest evaluation of the process value, and k_{Prop} and $k_{Integral}$ are the servo parameters. It is simple for you to replace this with your own algorithm if required.

The loop rate for execution of the PI algorithm can be from 500 µsec (2 kHz loop rate) upwards. It is generally sensible to make it the same as the F460 integration period so that fresh data is available at each iteration. Don't be tempted to run the servo quickly if it is not necessary. Generally you should aim to get the signal to noise ratio of the incoming signals as high as you can by increasing the integration time, to prevent the servo reacting to spurious noise.

24.1 A60 REAL TIME PROCESSING

The servo function is based in the A60 real time processing architecture, which provides an extremely flexible data collection and data processing environment for the advanced user. The system is described in Pyramid Technical Consultants' documents

PTC1-9-247 A60 Real-Time Controller Software and Configuration Architecture

PTC1-9-679 A60 Real-Time Controller Calculations

The behavior of the system when in real-time processing mode is controlled by xml files which you can edit as needed. For example, you can cause the F460 to put out a table of values on one or both of its analogue voltage outputs at a controlled rate, and log the resulting values. You can read inputs, do calculations on the values and generate an output value based on the calculations. These two examples in fact describe the two features required for the F460 servo, namely:

- the ability to sweep a process control value (a piezo motor position, for example) and log the resulting process variable (some arithmetic combination of the measured currents for example)

- the ability to form a process parameter from an arithmetic combination of the measured currents, execute a PID algorithm on it to form a new process control value, and output the result

24.2 PTC DIAGNOSTICG2 PID SERVO TAB

The servo function can be invoked from custom host software or via the serial ASCII interface. However it is convenient to set up and tune a servo system using the PTC DiagnosticG2, where you can get good visual feedback of the behavior of the overall system. You can see and plot the value of the process variable, the error terms and the process control output. You can alter the values of the key servo control parameters while the servo is running, and see the effect on the process. When you have chosen parameters, they can be locked down by adding them to an xml file – see next section.

Figure 63. Servo tab with servo running

The profile controls allow you to load an xml configuration file that defines the rate that the profile points are sent out to the analogue output, the process variable calculation and the data to be logged. The map file is simply a column of voltages to be output in csv format. Execute the map by clicking the Profile (Profile) button. Examine the resulting response curve and decide where you wish to start the servo, where to place any low and high limits, and what approximate magnitude and polarity the k_{Prop} and $k_{Integral}$ parameters will need to have.

The servo controls allow you to load a servo xml file that defines the loop period, the calculation of the process variable, which analogue output will be the process control, data to be sent to the Diagnostic GUI, the response to hitting limits and so on. Once you have loaded the file, the graphics will change to plot the parameters specified in the file. You will see the instantaneous value of the process variable you have defined ("process_value"). The target value ("c_process_target") simply tracks the instantaneous value at this stage.

Go to the setup tab and set the relevant analogue output voltage ("Out. Value") so that the process variable is where you want to regulate.

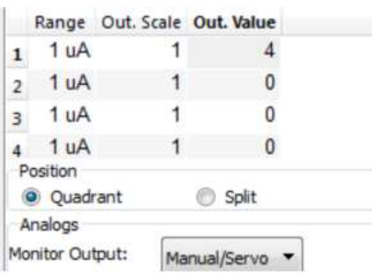


Figure 64. Direct analogue voltage control from the setup tab

When you click the Servo () button the servo will start running and you will see that the target value freezes, the following error and error sum error readings become active, and, assuming the servo terms are reasonable, the process control output (“C_dac”) will start to change in response to the errors.

k_{Prop} and $k_{Integral}$	These fields are where you set the controller terms. If you are working in a mode where the process variable is a current (any sum or difference of the inputs), the values will be large to reflect the large gain factor going from current to control voltage. This can be compensated if you require by adding a suitable gain factor normalization to the servo xml file. If the process variable is a ratio of currents, the controller terms will be closer to zero. If the response curve has negative slope where you want to control, the terms will need to be negative.
Low and High limits	The high and low limits allow you to constrain the process control voltage, for example to prevent the servo going to a region where the response curve has the opposite slop, or no slope. The default action is for the servo to suspend at the limits, but you can modify this behavior if needed.
Current low limit	The current low limit field is where you set a minimum sum of currents that must be present for the servo to be active. This prevents the controller responding to noise if the signal becomes small, for example if the beam is suddenly lost in a DCM application. As with the output limits the default is for the servo to be suspended, but you can alter this if you wish.
Reference	This is a normalizing factor that you can introduce to make the servo unresponsive to particular external factors. The incoming channel values are divided by this factor before being used in the PI algorithm. A typical use is in synchrotron light sources, where you want a DCM servo to respond to instabilities in the DCM itself, but not to the gradual decline in X-ray flux from the synchrotron. The host software sends to the F460 a value representing the synchrotron current periodically. You can change which values are normalized in the xml file; the fault is all of them.

Figure 65 shows how a process variable, the sum of all inputs from four photodiodes in this example, changes when the background illumination is decreased. The same change in illumination is repeated with servo is then enabled (just after 150 seconds in the plots), and the servo now compensates by increasing drive to an LED that makes up for the missing light.

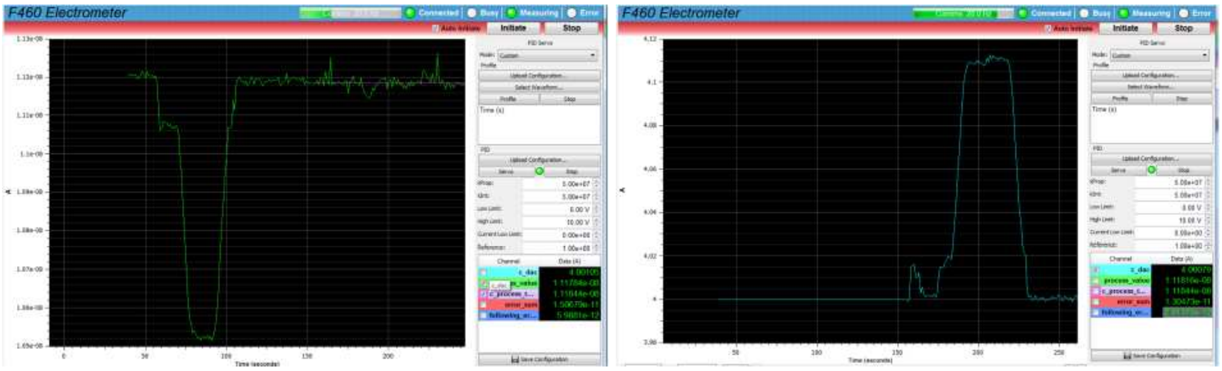


Figure 65. Servo tab with servo running. Left process values, right control output

24.3 XML FILES

We recommend that you develop a set of xml files to provide the profile scans and servo modes that you require for your applications. When you have settled on servo parameters that work well, the values can be added into the relevant servo xml file, and they will then override the values in the input fields on the PTC DiagnosticG2 screen. A set of example files was provided with the F460 documentation if you purchased the –S1 option, and these are a good place to start: edit the files to suit your needs. The can be edited with Notepad, but it is more convenient to use an editor that formats the file in a helpful way.

Some of the key entries in the servo xml file are:

24.3.1 Loop rate control

The rate is set to 10 Hz in this example.

```
<!-- Set the timeslice here to set the servo update period.
   It can be set to 500us or more. -->
<loopcontroller type="F460" name="F460_1" ip="192.168.0.6" timeout="50" timeslice="100000" >
```

24.3.2 Process variable definition

The process variable is defined as the sum of all four channels in this example.

```
<calculations>
  <calculation type="sum">
    <!-- Select a sensor or position channel here to choose the process
      parameter.
      If changing this, also change the current sum below. -->
    <arguments count="4" name="r_sensor_" start="1" />
    <channel name="process_value" />
  </calculation>
```

The process variable is defined as the ratio of the first two channels in this example.

```
<calculations>
  <calculation type="quotient">
    <!-- Select a sensor or position channel here to choose the process
      parameter.
      If changing this, also change the current sum below. -->
    <arguments count="2" name="r_sensor_" start="1" />
    <channel name="process_value" />
  </calculation>
```

24.3.3 Servo algorithm definition

In this example, the xml file calls the PI algorithm coded in the A60.

```
<calculations>
  <!-- Calculate the new output
    c_dac_new = c_dac_initial + k_prop * following_error + k_int * error_sum
      -->
  <calculation type="pid">
    <!-- The dac_initial value is reset above any time enable is false
        or reset is true.
      In effect, this means the Pid command sets the dac_initial value.
    -->
    <argument>c_dac_initial</argument>
    <argument>k_prop</argument>
    <argument>following_error</argument>
    <argument>k_int</argument>
    <argument>error_sum</argument>
    <!-- Don't use c_dac directly for low current limit check at the end -->
    <channel name="c_dac_new" />
  </calculation>
</calculations>
```

In this example, the same calculation is coded in the xml file using primitive calculations, and can thus be altered at will, for example to add a differential term, or to normalize the integral term to the loop rate.

```
<calculations>
  <!-- Calculate the new output -->
  <!-- Step 1: k_prop * following_error -->
  <calculation type="product">
    <argument>k_prop</argument>
    <argument>following_error</argument>
    <channel name="p2" />
  </calculation>
  <!-- Step 2: k_int * error_sum
    (Can do this at the same time as step 1) -->
  <calculation type="product">
    <argument>k_int</argument>
    <argument>error_sum</argument>
    <channel name="p3" />
  </calculation>
</calculations>
<calculations>
  <!-- Calculate the new output -->
  <!-- Step 3: DAC_initial + k2 + k3 -->
  <calculation type="sum">
    <!-- The dac_initial value is reset above any time enable is false
        or reset is true.
      In effect, this means the Pid command sets the dac_initial value.
    -->
    <argument>c_dac_initial</argument>
    <argument>p2</argument>
    <argument>p3</argument>
    <!-- Don't use c_dac directly for low current limit check at the end -->
    <channel name="c_dac_new" />
  </calculation>
</calculations>
```

24.4 SERVO OPERATING RANGE

Start the tuning process by running a sweep of the process control voltage and logging the process variable. This allows you to see working space that will be available to the servo. If the response is a simple increase in the process variable as the control voltage increases, then the servo will be relatively simple to stabilize. The average gradient of the curve will dictate the magnitude of servo parameters k_{Prop} and $k_{Integral}$. If the response is a simple decrease, the situation is similar, except that you will need negative servo parameters. If the response has a maximum or minimum, however, you will need to ensure that the servo cannot go past the point where the gradient changes sign, as it will immediately run up to its control voltage limit. This can be the situation for a DCM, where there is a peak in the response curve, and you need to limit the servo to operate on one side of the peak only. In the following example we'll take a simple case where the process variable is simply a single measured current, for example from an ionization chamber downstream of the DCM.

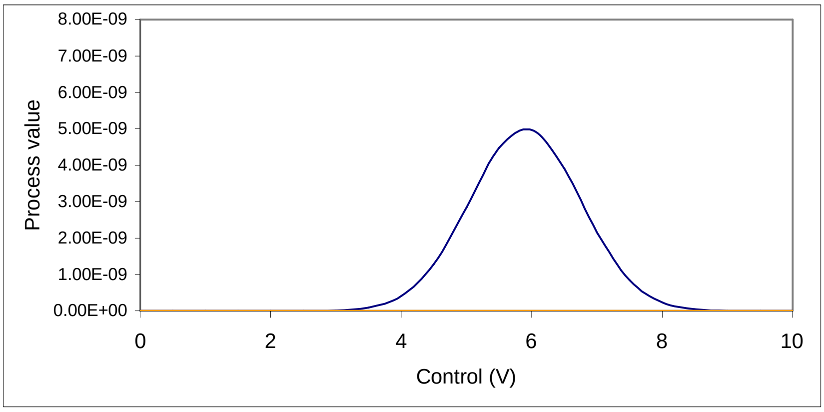


Figure 66. Simulated DCM crystal cage movement response curve

The general experimental requirement is for a stable and high beam flux from the DCM. If an operating point is defined on the side of the peak, towards the top, then a good compromise can be achieved where there is scope for the servo to move up or down the peak to stabilize the current, but not too much flux has been given up relative to the peak. Adjust the analogue voltage from the F460 that controls the piezo motor to the required operating point by direct command, and note that the expected current is being measured. This current value (the process variable value) is the one that will become the servo target once the servo is enabled.

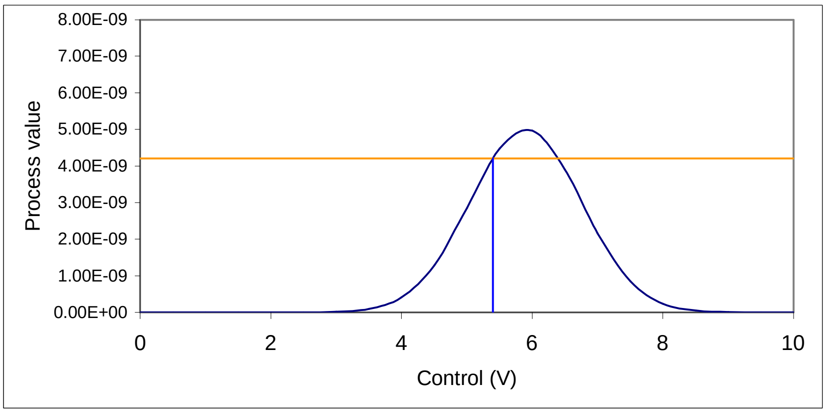


Figure 67. Selected operating point

In order to reduce the risk that the servo loses control if there are extreme perturbations, you should set low and high excursion limits on the analogue voltage output.

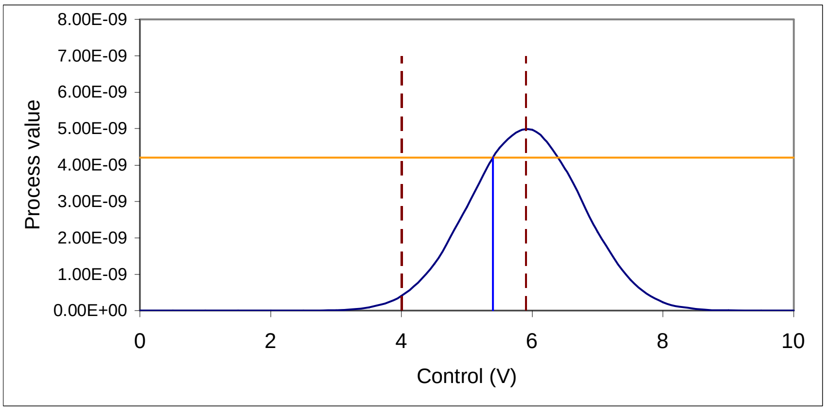
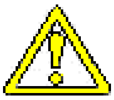


Figure 68. Constraining the process control operating range

24.5 SERVO TUNING



CAUTION

It is easy to set a servo system into oscillation if the parameters are set incorrectly, or to run off to one limit if the signs of the parameters are reversed. This may damage your equipment. Ensure you are familiar with the response of the system to the process control voltage before you start, and start any tuning exercise with small values of the proportional and integral terms.

Traditional tuning methods such as Ziegler-Nichols involve increasing the size of the controller terms until the loop becomes unstable, then reducing the values to particular proportions. First, set the integral term to zero and increase the proportional term until oscillation sets in.

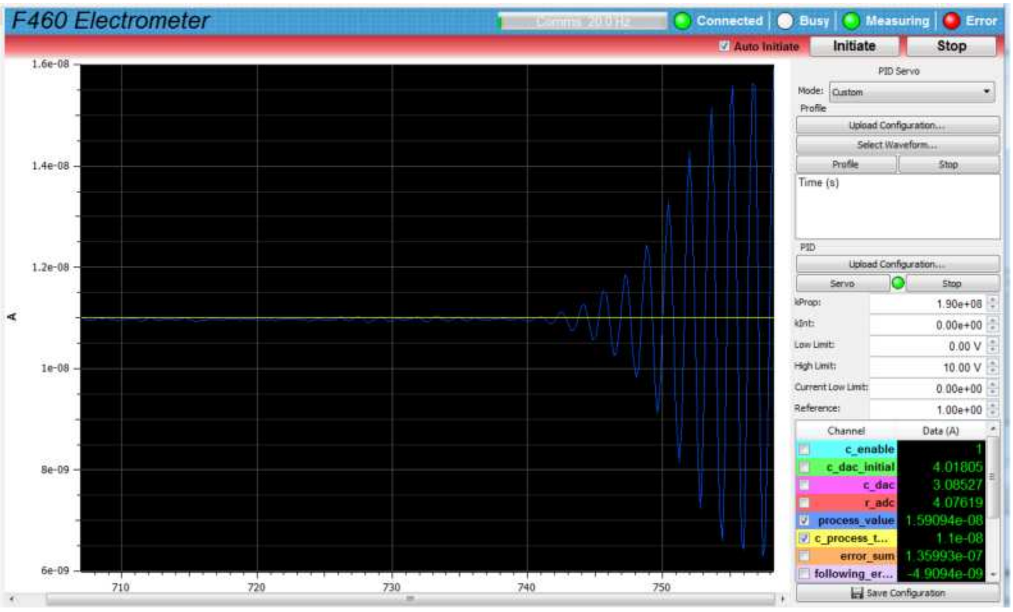


Figure 69. Oscillation when proportional term is increased

Reduce the proportional term to 45% of the value where instability starts. Proportional control is inadequate on its own because it cannot eliminate a certain residual error. So set an integral term that is 120% of the proportional term divided by the observed oscillation period, about 1.5 sec in the example here.

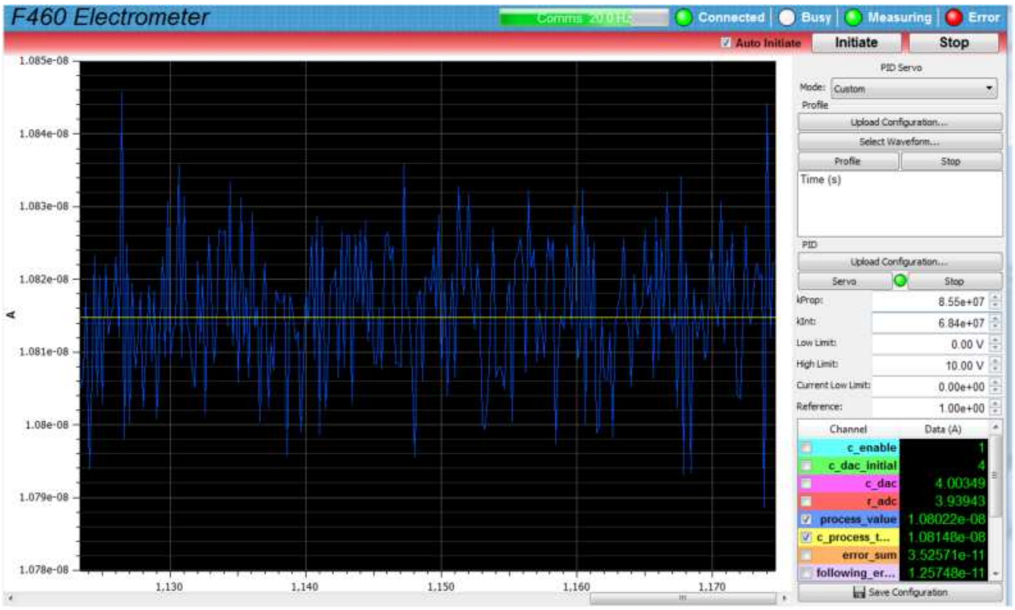


Figure 70. Ziegler-Nichols tuned servo

The result is a very responsive servo running quite close to the stability limit. It may become unstable at other places in the response curve, or if the system changes. It may also be inadvisable to run a system such as a DCM crystal cage piezo into oscillation just to obtain a tuning setting. Since applications such as these are more concerned with correction of relatively slow drifts and disturbances, we can tolerate a servo that may be slower to respond.

A simple but effective method for such applications is to start with low equal low values for k_{Prop} and $k_{Integral}$, such that the servo is almost unresponsive. Introduce some typical disturbance and observe the time it takes for the servo to restore the process target. Increase both terms together until the servo has sufficient responsiveness for your needs. In the example below, the terms were incremented 1e5, 5e5, 1e6, 5e6, 1e7 and the response to the same disturbance was observed for each case.

Figure 71. *Increasing servo terms until process variable responds adequately*

25 Firmware Updates

Firmware for the F460 comprises the embedded Linux operating system for the Ethernet NIOS processor, the real time application and the FPGA program. These are provided as a bundled zip file to ensure that the versions are compatible. Before starting an update you should ensure that the power to the F460 and the network connections are secure. An interruption during the update might make the F460 inoperable, in which case it must be returned to a service center to be reprogrammed.

Clicking the Update All Firmware button (**Update All Firmware...**) will open a dialog warning how long the task will take, and the instruction to keep the F460 powered.

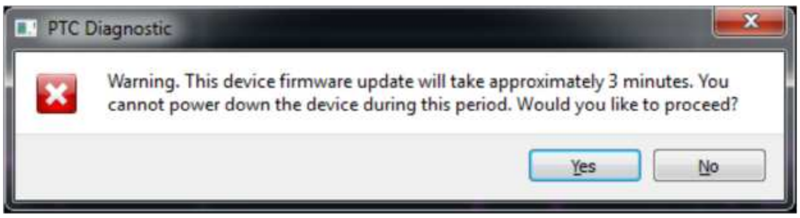


Figure 72. *Firmware update warning dialog*

If you answer yes, the open file dialog will open, and you can navigate to the new firmware file.

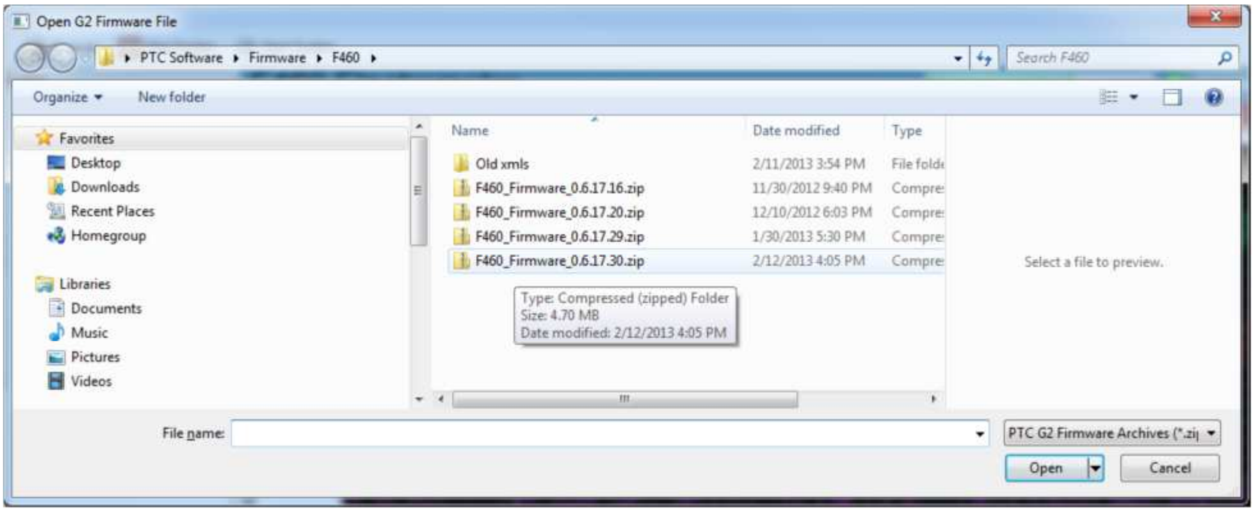


Figure 73. Selecting the new firmware file

During the update progress, you can monitor the progress in the message area.

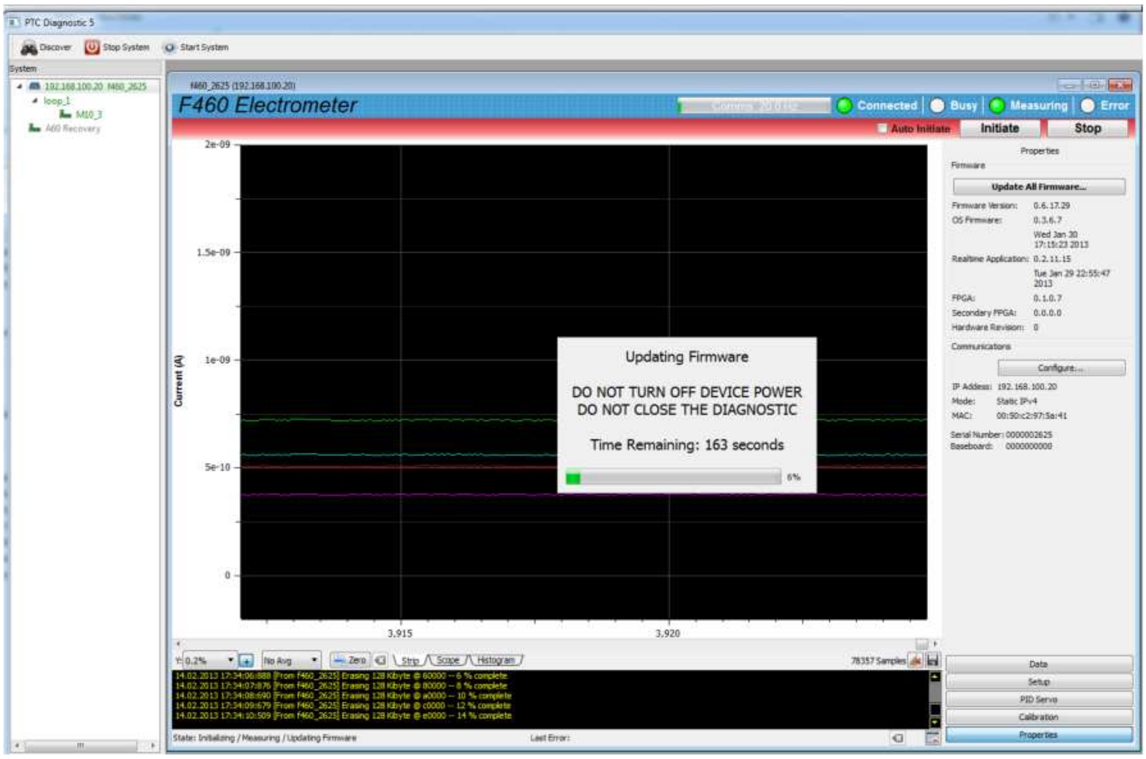


Figure 74. Firmware update in progress

At the end, you will see a message prompting you to re-power the device to start the new code. If you loaded the wrong version, there is still an opportunity to change your mind and load a different version by repeating the process.

Figure 75. Firmware update completed

26 Fault Finding

Symptom	Possible Cause	Confirmation	Solution
Current measurement inaccurate	Using sensor compensation inappropriately	Check setting.	Do not use sensor compensation when not required
	The device was calibrated with input currents present	Compare calibration parameters to previous values	Do calibration with no input connections
Unable to see an expected current	Using wrong range	Check range setting	Use current range appropriate to the expected input currents
	No return path for current	Trace full current path. Add a ground return from the current source to the F460 chassis.	Use correct cabling.
High noise levels	Using a high current range to measure a small current.	Try a more sensitive range	Use current range appropriate to the expected input currents
	Using a small integration period	Increase the integration period	
	Bad screening	Disconnect input; try a more direct or shorter connection with good screen.	Use good quality coaxial signal cable.
	Line frequency pickup	Take data with integration period 1/(Line frequency)	Use good quality coaxial signal cable and good grounding practice.
	Cable being flexed	Recheck with cable not moving.	Use anti-triboelectric signal cable.

Unit not collecting data	Inappropriate trigger mode	Select internal trigger mode.	Use appropriate trigger mode.
	Not initiated	Initiate device	Initiate device
	No external trigger present	Check signal at gate connector- must be TTL levels.	P
No or incorrect response to external gate	Trigger polarity incorrect	Check trigger polarity setting for acquisition start	Use correct setting.
Position readout does not change as expected	Connections to sensor not correct for the position function assumption.	Check connections	Use connections that match the position function.
	Sensor compensation is necessary but not enabled	Check setting	Use an appropriate sensor compensation
No or low high voltage	Shorted to ground in external circuit	Monitor HV reading zero or very low relative to setpoint. Monitor value recovers if F460 disconnected from the external circuit.	Eliminate shorts to ground.
	External load resistance too low.	Voltage recovers if setting is reduced.	Do not attempt to draw more than 1 watt from each high voltage supply. Higher power modules are available to special order.

High voltage not at setpoint	A high compliance source such as a charged particle beam is driving the HV electrode.	Monitor value recovers if F460 disconnected from the external circuit.	Change geometry to reduce beam strike.
Cannot set high voltage	Trying to set above the maximum allowed value soft limit.	Sets OK if a lower value is chosen.	If allowed, increase the maximum allowed value.
Unable to communicate via Ethernet	Incorrect IP address for F460 or host (not in the same subdomain).	Check settings of F460 host PC.	Use consistent IP addresses.
	Messages being blocked by anti virus software.	Disable anti-virus software	Set up allowed channels for F460 messages.
	Messages being blocked by firewall.	Disable firewall	Set up allowed channels for F460 messages or work without firewall.
Unexpected changes to F460 state	Another host is communicating with the F460.	Change IP address. Use a direct cable connection instead of a network. Look for unexpected connection over a VLAN.	Set up IP addresses and subnet masks to prevent conflicts.

Communications interruptions	Other processes on PC host interfering with comms ports.		Use a dedicated PC with simple configuration and minimum number of processes running.
	Excessive RS-232 cable length.	Check cable – it should not exceed 15 feet	Use RS-485 for long serial cable runs
Unable to connect on serial port	Another program is using the COM port.	Try to access the required port with a terminal program.	Choose another port or close down the other program.
	Incorrect port settings.		Correct the settings.
	Incorrect cable.		Make up a suitable cable.
	Mode switch is not set correctly		

27 Maintenance

The F460 does not require routine maintenance.

There are no user-serviceable parts inside.

CAUTION

High voltages may be present inside the case. Do not open the case when power is applied.

The F460 is fitted with a 500 mA automatically resetting positive temperature coefficient (PTC) fuse in the 24 VDC input. No user intervention is required if the fuse operates due to overcurrent. The fuse will reset when the overcurrent condition ends.

27.1 CALIBRATION

Run the internal calibration function of the F460 periodically. Make sure there are no signals present at the inputs when doing this. It is good practice to note any changes in the gain and offset parameters, because any trend would indicate that the affected channel might be out of specification.

Depending upon your application and your operational procedures, you may need to check the accuracy of the F460 against an external traceable current standard periodically. This can be done with any suitably-rated true current source such as the models available from Keithley. Since the F460 has high inherent accuracy, you must ensure that your reference source is in calibration. The compliance voltage of the reference source should be set to between 1.00 and 5.00 V, and you should ensure that there is a well-defined current return path from the F460 back to the source.

Take care that you are not confused by any sensor compensation when checking current measurement accuracy.

28 Returns Procedure

Damaged or faulty units cannot be returned unless a Returns Material Authorization (RMA) number has been issued by FMB Oxford Ltd. If you need to return a unit, contact FMB Oxford at CustomerSupport@FMB-Oxford.com or Sales@FMB-Oxford.com, stating

- model
- serial number
- nature of fault

An RMA will be issued, including details of which service center to return the unit to.

29 Support

Manual and software driver updates are available for download from the Pyramid Technical Consultants website at www.ptcusa.com.   Technical support is available by email from CustomerSupport@FMB-Oxford.com or Sales@FMB-Oxford.com.   Please provide the model number and serial number of your unit, plus relevant details of your application.

30 Disposal

We hope that the F460 gives you long and reliable service. The F460 is manufactured to be compliance with the European Union RoHS Directive 2002/95/EC, and as such should not present any health hazard. Nevertheless, when your F460 has reached the end of its working life, you must dispose of it in accordance with local regulations in force. If you are disposing of the product in the European Union, this includes compliance with the Waste Electrical and Electronic Equipment Directive (WEEE) 2002/96/EC. Please contact Pyramid Technical Consultants, Inc. for instructions when you wish to dispose of the device.

31 Declaration of Conformity

Declaration of Conformity

Issued by: Pyramid Technical Consultants, Inc.
1050 Waltham Street, Lexington MA 02421, USA

The undersigned hereby declares, on behalf of Pyramid Technical Consultants, Inc. that the referenced product conforms to the provisions as listed. Refer to the document: *Extension of testing and analysis to the PTC product line, December 10, 2007,* and its continuations, and the *I400 Technical Construction File* for detailed testing information.

Product:	F460 Quad Current Monitor
Year of initial manufacture:	2012
Applicable Directives:	73/23/EEC Low Voltage Directive: Laws for electrical equipment within certain voltage limits 89/336/EEC – EMC Directive: Laws relating to electromagnetic compatibility
Applicable Standards:	IEC 610101:2002 (2nd Edition) UL 61010-1:2004 EN 61326: 1997+A1:1998+A2:2001 EN 55011:1998, A2:2002 EN 61000-6-2:2001 – Electromagnetic Compatibility Generic Standard, Immunity for Industrial Applications
Issuing Agencies:	Safety: TUV Rheinland North America. 12 Commerce Rd, Newtown, CT 06470 USA EMC: TUV Rheinland North America. 12 Commerce Rd, Newtown, CT 06470 USA
Applicable Markings:	TUV, FCC, CE
Authorized by:	R.P. Bu~~ President, Pyramid Technical Consultants, Inc.
Date:	18 Feb 2013

The Technical Construction File required by theses Directives are maintained at the offices of Pyramid Technical Consultants, Inc, 1050 Waltham Street, Lexington MA 02421, USA
A copy of this file is available within the EU at the offices of Pyramid Technical Consultants Europe, Ltd, Suite 3 Unit 6-7 Henfield Business Park, Henfield BN5 9SL, United Kingdom.